# Exploring Energy Trade Possibilities between South Asia and OPEC

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**Contents**

## SYNOPSIS

This study is an exercise into assessing possibilities for energy trade between South Asian Countries (SAC) and the Organization of Petroleum Exporting Countries (OPEC). It does this against a background of changes on the international and regional economic fronts and their likely impacts on energy investments. The study tends to focus on natural gas as there are strong arguments that are pushing for its increased use, arguments based on considerations of resource availability, its inter - fuel substitutability, cost advantages arising from technological developments, and environmental benefits.

The argument that is developed in the study is that there is a mutual advantage for OPEC and SAC to look to each other more closely for that vital component of investment strategies - the need for certainty of demand and supply to allow dedicated investments to be put in place. OPEC needs to invest in increasing productive capacity if it is to meet future incremental world oil demand. However, it is deterred from this because of the uncertainty in future oil demand given emerging environmental trends that may reduce the demand for oil. The logic of future investment seems to lie in investments in increasing gas production and exports, but even here there is need to ensure certainty of demand.

Countries of South Asia are growing fast. All projections indicate steady increases in energy demand and most of it in terms of petroleum products, especially middle distillates, despite attempts at energy conservation. The rates of growth in demand outweigh projections of supply, indicating that net imports of oil are but inevitable. These countries are concerned with reliability of supplies of oil and of gas especially in cases where new investments are being made premised on the expected availability. A number of South Asian countries do have good reserves of natural gas, in many cases better than that of crude oil. On these and on emerging environmental arguments for increased gas use over oil use, there is a strong case here for investment in gas developments.

However, gas reserves in these countries are not expected to be sufficient to make investment for a gas based industry viable, unless gas imports are an option in the future. It is argued that countries of South Asia can come to represent a centre for certain demand for OPEC oil and gas and, conversely, that OPEC can represent a potentially secure source of supply given traditional trading and political alignments. This will enable dedicated investment to be undertaken both to increase production capacity and to invest in infrastructural and gas based projects.

Hitherto, the relationship between OPEC and South Asia has always been clothed in the rich-poor dichotomy, with the poor countries looking for aid and special assistance from OPEC. It is argued in this report that while members of OPEC are rich because of the depletion of their oil resources and their conversion into financial assets, they are not developed economies in the sense that these are commonly understood. The relevant social and economic indicators point to the relatively early stages of development in these countries, and in this context, countries of South Asia may have valuable experience to offer in terms of industrial and technological expertise, especially in the oil and gas and power equipment supply industry. There is also a real opportunity for co-operation between producer and consumer countries in gas based downstream industry.

Section I looks at OPEC at the turn of the century, their oil and gas potential and their concerns in investing in necessary capacity to bring the oil and gas to the market. Sections II - V focus on the South asian energy economies. Section II looks at the energy-economy interactions; Section III examines energy resource supply potential and consumption; Section IV discusses trends in sectoral energy consumption to 2010 in a base case situation, and Section V develops a scenario where there is a

significant gas push into various sectors of the economy. Section VI deals more generally with issues of relevance to these economies in developing natural gas markets, whether based on indigenous or imported gas, with an emphasis on the latter. And finally, Section VII makes a case for a greater trade co-operation in energy related industry, both downstream, and in the equipment and services supply industry.

## SECTION I: OPEC in the 1990s and Beyond

OPEC is an organization of 13 developing countries spread across 3 continents, set up as a collective defence mechanism for countries heavily dependent on oil exports. Its main aims included group protection from situations arising from:

- pricing and/or production policies of foreign oil companies that could destabilize the host countries
- excessive economic dependence on industrialized countries and their economic polices
- instability of the energy market and its negative impact on the oil exporting countries' balance of payments and development.[1]

Since its formation over 30 years ago and successful action in controlling oil prices, OPEC has acquired a reputation for power and wealth which is in a sense rather cosmetic. If one were to closely examine the development indicators of the member countries it would become immediately apparent that these countries are still at an early stage of development, sharing a number of the criteria which define the developing world (Tables I.1, I.2, I.3): (i) They are still dependent for their wealth on a single primary commodity, oil, with all the attendant difficulties that accompany dependence on a single commodity, (ii) they have a very narrow manufacturing base, (iii) except for Indonesia, and perhaps Ecuador, they have no major exports other than oil, (iv) they all import food and (v) six of them are heavily indebted countries.[2] The three tables below summarize these development indicators for the member countries. Tables I.2 and I.3 point to a need for OPEC countries to diversify their economies.

**Table I.1**: OPEC 1990 - Main socio-economic indicators.

| Indicator/country | Pop. (mn) | GNP per capita (US $) | Ann.@ oil prod. (10^3 bbl/d | Life Expectancy at birth (yrs) | Adult literacy rates (%) |
|---|---|---|---|---|---|
| Nigeria | 115.5 | 290 | 1605 | 52 | 49 |
| Algeria | 25.1 | 2060 | 698 | 65 | 43 |
| Indonesia | 1788.2 | 570 | 1209 | 62 | 23 |
| Ecuador | 10.3 | 980 | 287 | 66 | 14 |
| Venezuela | 19.4 | 2560 | 1732 | 70 | 12 |
| Gabon | 101 | 3330 | 197 | 53 | 39 |
| Iran | 5508 | 2490 | 2934 | 63 | 46 |
| Libya | 4.5 | 5310 | 1101 | 62 | 36 |
| Iraq | 18.9 | .. | 2830 | 63 | 40 |
| Saudi Arabia | 14.0 | 7050 | 4936 | 64 | 38 |
| Kuwait * | 2.0 | 16150 | 1543 | 74 | 30 |
| UAE | 1.6 | 19860 | 1917 | 72 | .. |
| Qatar | 0.4 | 15860 | 395 | 70 | .. |
| Low Income Country Average | | 350 | | 62 | 40 |
| OECD Average | | 20170 | | 77 | <5% * |

* 1989 figures; Source. **World Development Report 1992**, * less than 5% illiteracy.
@ **Oil and Gas Journal, December, 1991**

[1]. Z.Mikdashi **Transnational Oil: Issues, Policies and Perspectives**, Frances Pinter, London, 1989, p 45.

[2] Total external debt as a percentage of GNP in 1990 for the six countries was as follows: Nigeria - 111%, Ecuador - 121%, Gabon - 86%, Indonesia - 66%, Algeria - 53% and Venezuela - 71%. Source: **World Development Report 1992**

| **Table I.2**: OPEC 1990 - Sectoral Share of GDP (%). | | | | |
|---|---|---|---|---|
| Indicator/country | Agriculture | Industry $ | Manufacturing | Services |
| Nigeria | 36 | 38 | 7 | 25 |
| Algeria | 13 | 47 | 12 | 41 |
| Indonesia | 22 | 40 | 20 | 38 |
| Ecuador | 13 | 42 | 23 | 45 |
| Venezuela | 6 | 50 | 20 | 45 |
| Gabon | 9 | 49 | 7 | 42 |
| Iran | 21 | 21 | 8 | 58 |
| Libya | 5 | 63 | 3 | 33 |
| Iraq | .. | .. | .. | .. |
| Saudi Arabia | 8 | 45 | 9 | 48 |
| Kuwait * | 1 | 56 | 9 | 43 |
| UAE | 2 | 55 | 9 | 43 |
| Qatar | .. | .. | .. | .. |

* 1989 figures; .. Not available;
Source: **World Development Report 1992**
$ Industry includes manufacturing, mining, construction, electricity, gas and water.

| **Table I.3**: OPEC 1990 _ Percent Share of Merchandise exports. | | | | | |
|---|---|---|---|---|---|
| Indicator/ country | Fuels, minerals, metals | other primary | textiles & clothing | machinery | other manuf |
| Nigeria | 97 | 2 | 0 | 0 | 0 |
| Algeria | 96 | 0 | 2 | 2 | 0 |
| Indonesia | 48 | 16 | 11 | 14 | 34 |
| Ecuador | 49 | 48 | 0 | 0 | 2 |
| Venezuela | 87 | 2 | 1 | 2 | 9 |
| Gabon | 69 | 21 | 1 | 9 | 0 |
| Iran | 98 | 21 | 1 | 9 | 0 |
| Libya | 100 | 0 | 0 | 0 | 0 |
| Iraq | 35 | 41 | 0 | 0 | 24 |
| Saudi Arabia | 88 | 1 | 0 | 0 | 11 |
| Kuwait * | 96 | 0 | 1 | 3 | 0 |
| UAE * | 91 | 2 | 2 | 5 | 1 |
| Qatar | .. | .. | .. | .. | .. |

* 1989 figures; Iraq's 1990 shares are not typical of its export composition; Source: **World Development Report 1992**

It is apparent from the fluctuations in their fortunes, and especially those of the 1980s, that their wealth is still very much tied to the level of world oil demand,[3] and that projections of world oil demand and supply and OPEC share of the oil supply are crucial in determining their future prospects. However, such projections are made based on past and currently emerging trends, and this thus requires a slight digression into the factors that explain current world supply, demand and productive capacity.

The 1950s and the 1960s were a period of high world economic growth fuelled by cheap oil from West Asia. Following the Arab-Israeli war in 1973, oil prices rose from a low of $3/bbl to around $10/bbl, leading to an economic recession in 1973/74 as consuming countries adjusted to the new oil situation. By the end of the seventies, political unrest in Iran resulted in a reduction of Iran oil in the international market, creating an uncertainty about oil supplies which OPEC was able to use to its advantage in controlling oil prices, triggering off a price increase from $13/bbl in 1978 to $30/bbl in 1979. This steep increase and fears of further increases prompted a large effort at energy conservation and a movement away from oil as economies, essentially the OECD economies, began a process of industrial restructuring away from energy intensive industries towards the services sector. At the same time, attempts by oil consuming countries to control inflation resulted in a global recession. Consequently, world oil demand fell from 37.4 mmbd in 1973 to 31.5 mmbd in 1983, causing a steady decline in oil prices. There thus emerged a capacity overhang in the mid-1980s, with productive capacity in excess of demand, causing a further fall in oil prices.[4]

The fall in oil revenues created pressures within OPEC between those members who are low absorbers (but with large reserves) and the high absorbers (but with low reserves) with the former wanting to keep oil prices low to ensure market shares, while the latter preferred to maximize revenues from limited reserves. By 1985, the world economy emerged from the recession and by end 1985, OPEC decided to pursue market shares, causing oil prices to fall further. The fall in prices since the early 1980s created a surge in oil demand to about 47.9 mmbd by 1986. Oil demand has been increasing steadily since then and was about 52 mmbd in 1991. Table I.4 summarizes these changes in world oil demand (outside the erstwhile CPEs).

**Table I.4**: World Oil Demand (mmbd)

| | |
|---|---|
| 1973 | 37.4 |
| 1983 | 31.5 |
| 1985 | 46.4 |
| 1986 | 47.9 |
| 1987 | 48.8 |
| 1988 | 50.3 |
| 1989 | 51.2 |
| 1990 | 52.0 |
| 1991 | 52.1 |

Source: **Oil and Gas Journal, several issues.**

[3] An indication of such fluctuations are the swings in their oil revenues which rose from $ 23 billion in 1973 to $ 275 billion in 1980, fell sharply to $77 billion in 1986 and rose again to $ 110 billion in 1990.

[4] In 1985, the world potential to produce oil exceeded demand by about 8 - 10 million barrels a day, most of the excess capacity being in the OPEC countries, especially those of the Gulf.

One of the key factors explaining the fall in world oil demand in the 1970s and early 1980s, were the fundamental changes in the world's energy markets since 1973, in part a response to the two oil price rises. Energy intensities declined in all OECD countries; 15% less energy was required per unit GDP in 1985 as compared to 1973, with that of oil having fallen by 30%. This fall in intensities was partly due to a substitution away from oil and partly due to more efficient use of energy. However, this did not apply to the developing world where the intensities continued to rise. The table below summarizes the change in energy and oil intensities for the OECD and the developing countries in the period 1975 to 1990.

**Table I.5**: Energy and Oil intensities in different regions (toe/$1000 GDP)

| **Region** | 1975 | 1990 | 1990/75 (%) |
|---|---|---|---|
| **OECD** | | | |
| Energy | 0.51 | 0.41 | -20.2 |
| Oil | 0.27 | 0.18 | -34.7 |
| **DCs** | | | |
| Energy | 0.43 | 0.56 | 28.7 |
| Oil | 0.26 | 0.28 | 9.2 |
| **World** | | | |
| Energy | 0.50 | 0.44 | -11.2 |
| Oil | 0.27 | 0.20 | -25.9 |

Source: **OPEC Review,** Winter 1991, p 352.

In 1973, OPEC supplied about 53% of world oil production. One of the consequences of the oil price increases was that a lot of non-OPEC oil, especially offshore oil, became profitable to produce. As a result non-OPEC production took off, rising from about 27 mmbd in 1973 to about 40.5 mmbd in 1985. This significantly reduced the market share of OPEC oil as seen in Table I.6. However, as oil prices declined, investment in oil exploration and development began to level off and so did the share of non-OPEC crude. By 1991, non-OPEC crude was at the level it was in 1973, that is at about 27 mmbd. Post 1985, therefore the market share of OPEC crude has been on the rise, contributing about 39% of world oil supplies in 1991 or about 23.4 mmbd. Saudi Arabia was the largest producer with 8.2 mmbd, followed by Iran with 3.4 mmbd and the UAE with 2.4 mmbd.

**Table I.6**: OPEC share of world oil production (%)

| | |
|---|---|
| 1973 | 53.6 |
| 1979 | 48.0 |
| 1985 | 30.0 |
| 1989 | 36.0 |
| 1990 | 38.5 |
| 1991 | 39.0 |

Source: **Oil and Gas Journal,** several issues

Projections of oil supply and demand in the 1990s

**Oil and Gas Journal's** semiannual survey of forecasters of world oil demand for the 1990s places oil demand between a low of 52 mmbd to a high of 61.4 mmbd with a mean value of 57 mmbd by the year 2000.[5] These forecasts reflect best estimates of growth rates of GDP of about 3% p.a in the period 1990 - 2000. The projected rates of growth of oil demand are about 1.7% p.a. Expectations are that non-OPEC oil will supply about 22.3 mmbd in the year 2000, with the balance coming from OPEC. This would imply an OPEC share of over 60% of world supplies at about 39.1 mmbd. These projections do, however, depend on the shift to gas, the exports from the erstwhile Soviet Union into the international market, and political instabilities in West Asia which may impact export capability or prompt non-price demand shifts away from its oil. The main factor in favour of the projected increase in OPEC share of future world oil supply is its very comfortable reserves position and the reduced ability of non-OPEC oil to do the 1980s act in the 1990s and beyond. Table I.7 shows that the world's remaining reserves of conventional oil are located mostly in the Gulf, and controlled by OPEC. USA, Mexico, China and the OECD Europe contain only a small proportion of the world's remaining recoverable oil and proved oil reserves. Moreover, the time to which most current non-OPEC output can be sustained is a short period of 10-15 years.

**Table I.7**: Reserves, Remaining Recoverable Oil

[(%) of World total]

| | Proved Reserves | Remaining Recoverable Oil |
|---|---|---|
| OPEC | 78 | 60 |
| Gulf | 65 | 49 |
| Erstwhile USSR | 6 | 11 |
| USA | 3 | 6 |
| OECD Europe | 1 | 3 |
| China | 3 | 4 |

Source: **Oil and Gas Journal**, 23 September 1991, p 63.

OPEC Oil and Gas Reserves Position

There has been a sharp increase in oil reserves of OPEC countries in the 1980s. The countries whose reserves in 1990 were sharply higher than in 1980 are: Iran - 60%, Iraq - 223%, Kuwait - 45%, Saudi Arabia - 56%, UAE - 234% and Venezuela up - 227%. In 1992, crude oil reserves of OPEC countries stood at 104.6 billion tonnes, while that of natural gas stood at 49 trillion cubic metres. The detailed reserves position of OPEC member countries as of 1 January 1992 is given in the table below.

[5] **Oil and Gas Journal**, December 25, 1989.

| Table I.8: OPEC reserves of crude oil and gas (as on 1.1. 1992) | | | | |
|---|---|---|---|---|
| OPEC members | Crude oil (MMT) | R/P[6] ratios (Yrs) | Natural gas (BCM) | R/P ratios (Yrs) * |
| Algeria | 1251 | 32 | 3299 | 132 |
| Gabon | 99 | 7 | 13 | |
| Libya | 3100 | 42 | 1218 | 84 |
| Nigeria | 2434 | 26 | 2965 | |
| Ecuador | 211 | 15 | 110 | |
| Venezuela | 8038 | 69 | 4794 | 56 |
| UAE | 13353 | 110 | 5814 | 659 |
| Indonesia | 895 | 13 | 1836 | 64 |
| Iran | [redacted] | [redacted] | 17000 | 437 |
| Iraq | 13600 | 132 | 2690 | 117 |
| Kuwait | 12784 | 240 | 1359 | 69 |
| Qatar | 507 | 26 | 4587 | 208 |
| Saudi Arabia | 35067 | 86 | [redacted] | 906 |
| Total @ OPEC<br>TOTAL NON-OPEC | 104637<br>31255 | | 49075<br>76758 | |
| Source: @ - figures may not tally because of rounding; Source: **Oil and Gas Journal**, December 30, 1991; * WWI, **State of the World 1992**, p 40. | | | | |

It is thus abundantly clear that in the 1990s, OPEC countries are still firmly in control over the world's oil and gas reserves, and will be called upon to provide an increasing portion of world oil demand.

While OPEC currently accounts for 39% of the world's proven reserves of natural gas, some 49,075 bcm, its share of global natural gas consumption is 7%. Over 50% of OPEC gas is associated gas, but there are a number of very large free gas fields in Qatar, Saudi Arabia and Indonesia. In 1960, over 50% of OPEC gross production of gas was flared, with the figure rising to about 60% in 1970. Subsequently, the share of flared gas has fallen indicating increased gas utilization. In 1990, the portion of gas that was flared was down to 13%.

It is believed that the gas reserves of OPEC may be even higher than presently estimated given the fact that so far the gas discovered has been in the course of searching for oil and no concerted effort has been made to search for gas. Table I.9 below provides a summary of OPEC and non-OPEC proven reserves and gross production over three decades.

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[6] If reserves remaining at the end of the year are divided by production in that year one gets the length of time that the remaining reserves would last if current production continued. It is an important indicator of sustainable production capacity and can be used as an aid to planning since it can be used to calculate required additions to reserves when production is growing at a defined rate or to calculate the level of production if the addition to reserves required to maintain growth cannot be sustained. See, P.Odell and K.Rosing, **The Future of Oil: World Oil Resources and Use**, 1983, p 56.

| Table I.9: OPEC/Non-OPEC Reserves and Gross Production of Natural Gas (BCM) | | | | | | |
|---|---|---|---|---|---|---|
| Year | OPEC | | | NON-OPEC | | |
| | Proven Reserves | Gross Prod. | R/P (yrs) | Proven Reserves | Gross Prod. | R/P (yrs) |
| 1960 | 7377 | 46 | 161 | 11814 | 542 | 22 |
| 1970 | 15859 | 174 | 91 | 29142 | 1148 | 25 |
| 1980 | 31575 | 273 | 116 | 51804 | 1521 | 34 |
| 1990 | 49507 | 425 | 117 | 81413 | 2041 | 40 |
| Source: CEDIGAZ, BP Statistical Review of World Energy, OPEC Secretariat | | | | | | |

It is clear from Table I.9 that OPEC is very comfortably placed in terms of its gas reserves with R/P ratio almost three times that of the non-OPEC countries. Moreover it has very low gas consumption levels at 0.3% of its current reserves as compared to the USA which consumes 11.4%, Western Europe 4.33% and Japan over 143% of its gas reserves.[7] There is very evidently a large export potential for natural gas in these countries given this gap between supply and local demand. So far only Algeria, Indonesia, Libya, Iraq, the United Arab Emirates and Iran have been in the gas export business. But Nigeria, Qatar and Venezuela plan to export gas soon. In 1990, over 87% of total OPEC exports of natural gas were from just two members: Algeria and Indonesia which together exported about 59 BCM of natural gas with around 75% of these exports being through liquefied natural gas (LNG), the balance being through pipeline.

Of relevance to the countries of South Asia given their proximity are potential exports from Qatar, Iran, Indonesia, and perhaps, Abu Dhabi. Qatar has 4587 BCM of proved reserves as of 1.1.92, of which about 92% are in a single field, the North field being operated by Qatar General Petroleum Company in consortium with other oil companies. This is an offshore field with free gas at a depth of 2470 and 2830 m. CEDIGAZ reports that plans are to develop the field in three phases: the first phase will supply 11.32 mmcmd of gas to the local industry; the second phase envisages the building of a pipeline system to export 22.64 mmcmd to the Gulf states and possibly to Pakistan; the third phase involves exporting 4 Mt/y of LNG to Japan and India.

Indonesia has 1836 BCM of natural gas of which it produces about 50 BCM giving an R/P ratio of 38 years. Gas flared is about 6% of production. The major part of natural gas is used for energy purposes either for domestic or export markets, while a small amount is used as feedstock in fertilizer and petrochemical industries. Various gas fields remain undeveloped due to limited export markets for LNG, inadequate infrastructure for domestic consumption and the absence of a nearby industrial market. Despite this, Indonesia has become the world's largest exporter of LNG, supplying nearly 40% of the global market.

Iran Has 17000 BCM of natural gas reserves making it the richest of the OPEC gas countries. Of this about 3000 BCM are around the triangle of Bandar Abbas - Firoozabad - Port Booshehr and 5000

[7]. Simon Adewole, 'OPEC natural gas exports: past, present and future', OPEC Review, Spring 1992, pp 71 - 94, at p 75.

BCM are in the offshore area off Bandar Abbas and Booshehr. Iran gas has remained under-utilized both in terms of local markets and export. However, there is an increasing interest in Iran to export this gas both to other OPEC countries and to the rest of the world.

OPEC Productive Capacity

It is evident from this discussion of oil and gas reserves that OPEC has a firm share of future oil and gas production and export potential. However, whether this potential can be realized depends very much on their ability and willingness to develop their productive capacity. OPEC's sustainable crude oil production capacity is currently around 28 - 29 mmbd, with the Gulf countries' capacity totalling about 20 mmbd. At present OPEC production levels of 23 - 24 mmbd, there is a surplus of about 5 - 6 mmbd of productive capacity which is seen more as a strategic excess capacity. Since the Suez crisis in 1956, international oil companies backed by their governments have been maintaining a margin of excess production capacity as cushioning against possible supply disruptions. This practice has been followed by the governments of oil producing countries with a view to increasing their market shares when oil demand rose. This surplus capacity came in handy, for example in the recent Gulf crisis, when the stoppage of Iraqi and Kuwaiti crude caused a shortfall of about 4 mmbd of oil in the international markets. The deficit was met by Saudi Arabia (3 mmbd) and the balance was made up by other OPEC members, thus stabilizing oil prices. Thus, surplus capacity can prove very much in the interests of the consumers, but they can also be detrimental to the interests of producers, as happened in the mid-1980s, when the supply overhang exerted a downward pressure on oil prices.

However, the crucial issue with respect to productive capacity today is not this spare capacity maintained for commercial and security reasons, but the increases in productive capacity required to meet the projected increases in oil demand by 2000. If OPEC is to supply about 39 mmbd of oil, it implies a 10 mmbd excess over its current productive capacity. The key question facing OPEC countries in doing so is the level of investment required. It is estimated that OPEC requires $60-$100 billion to increase oil production capacity by 10 mmbd between 1990-2000 depending on the level of investment per peak daily barrel that is assumed. Another $100 billion will be needed in this period to produce and transport 70 BCM/year of natural gas to meet European demand.[8] CEDIGAZ estimates that a new LNG project in 1991 with a capacity of 6 -8 BCM/year would require a financial commitment of $5 billion. It is clear that large sums of money are required if the potential for exports is to be met. OPEC, however, believes that the real obstacle to expanding production capacity is not so much raising the requisite finance but ascertaining the demand for oil and gas in consuming centres.[9]

In the face of rising environmental concerns about the use of fossil fuels and its implications for global warming and worries about the international community imposing a carbon tax, the main concerns of OPEC are:

(i) whether the future trend of the energy market is to move away from oil. The International Energy Agency predicted that the 1990s could well be the decade of natural gas going by the policies favoured and pursued by the OECD countries. IEA predicts that this increase in gas demand

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[8]. Petrostrategies: The World Energy Weekly, 22 July 1991, p 2 and 5.

[9] 'Editorial', OAPEC Monthly Bulletin, April 1990

will continue to grow in the next century.[10] The driving force for gas growth is seen to be power generation and cogeneration especially in OECD Europe where gas consumption is poised to double in this decade. The main push for this move into gas is perceived to be environmental given the lower sulphur and other emissions from gas. However, security of supply considerations related to oil dependencies is also one of the reasons for the diversification into gas. Another study by Purvin and Gertz, Inc. sees a sharp rise in gas demand in the Asia Pacific with a resultant toughening in competition for available gas supplies. The demand growth in this region of the world is explained not only by the power generating but also other sectors of the economy. However, potential gas use in power generation is supported by the high growth in electricity demand and limited existing generating capacity in many countries.[11] Table I.10 below summarizes projections for world gas demand to 2010.

**Table I.10**: Projections of Natural gas demand to 2010 by region

(TCM)

| Region | 1990 | 2010 | AAGR (%) |
|---|---|---|---|
| OECD Europe | 0.08 | 0.5 | 2.77 |
| Eastern Europe | 0.06 | 0.11 | 3.53 |
| North America | 0.6 | 0.8 | 1.75 |
| Asia - Pacific * | 0.12 | 0.26 | 3.76 |
| Total | 1.04 | 1.67 | 2.41 |

Source: IEA; * Projections by Purvin & Gertz Inc.
Figures may not tally because of rounding up.

(ii) what role is natural gas likely to play relative to OPEC oil and what implications do these trends have for investment policies by OPEC.

(iii) the position of OPEC gas relative to non-OPEC gas given that location of gas reserves are more dispersed than those of oil and that reserve locations are important determinants of gas transportation costs.

The concerns of OPEC are summed up in this extract from the speech of Dr. Subroto, Secretary-General of OPEC, delivered at Oxford,

> Energy Security lies at the heart of both producers' and consumers' interests. For the oil producers grouped within OPEC, energy security means assured access to the markets of oil importing countries, maintenance of the share of oil in total energy consumption in the long term, and fair and stable prices that enable the producers to finance their plans for sustainable development during the lifespan of their oil resources. For the consumers, energy security implies the availability of oil supplies at reasonable prices, thus enabling them to continue to enhance their economic growth and competitiveness.[12]

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10 Oil and Gas Journal, November 4, 1991, p 45.

11 Hydrocarbon Processing, November 1991, p 37.

12. Speech delivered in Oxford, Uk, on September 3 1991, reproduced in OPEC Bulletin, October 1991.

This report in a way seeks to address this concern by focusing on the countries of the South asian region, where populations are large and growing, where there is a low per capita energy consumption but rising with economic growth. Growth in energy consumption is expected in all sectors. These are countries with large, upwardly mobile middle classes which by their sheer numbers represent a sizeable market for gas based consumer products such as cooking fuels and plastics; countries where large amounts of fertilizers are required to meet the growing food needs of their populations. This report explores energy trade possibilities between OPEC and the countries of South Asia, with a special focus on gas, arguing that while the former are concerned with certainty of demand in order to undertake new investments in productive capacity, the latter are concerned with reliability of supplies of oil and gas, especially in cases where new investments are being made premised on the expected indigenous gas availability. It is argued that these countries with their large and hungry energy markets can provide some reasonable certainty of demand.

## Section II: Energy Economy of the South Asian Region

The countries of the South Asian region that are included in this study are Bangladesh, India, Nepal, Pakistan and Sri Lanka. These nations are classified as Low Income Developing Countries by the World Bank, with per capita GNPs in 1990 ranging from $170 for Nepal to $470 for Sri Lanka (Table II.1). The average level of per capita GNP of this group of countries is about one-sixth of the level for middle income countries ($2,220) and less than 2 per cent of the average per capita GNP for the high income countries ($19,590).

**Table II.1**: Per Capita GNP (1990).

| Country | GNP per capita (1990 US $) |
|---|---|
| Bangladesh | 210 |
| India | 350 |
| Nepal | 170 |
| Pakistan | 380 |
| Sri Lanka | 470 |

Source: World Development Report, 1992

With the exception of Sri Lanka, these countries also belong to the category of countries with Low Human Development[13]. Some important indicators of Human Development are summarised in Figure 1.

Clearly, Sri Lanka has achieved world standards as far as the above indicators are concerned, whereas in the other countries the low levels of literacy and life expectancy along with high infant mortality rates reflect a poor quality of life for a major part of the population. Poverty levels are high and out of the total poor of about 1200 million for the entire world nearly half are inhabitants of the South Asian region. The World Bank estimates that 49% of the people of the South Asian region are still below the poverty line, defined in 1990/91 as $420 annual per capita income.

The pervasive poverty in the region does not, however, imply the absence of efforts towards economic development. During the 1980s the economies of the region performed fairly well in terms of real GDP growth, with growth rates varying between 3.8% for Sri Lanka to 6.2% for Pakistan. The rapid rates of population growth have, however, precluded aggregate production growth from being translated into similar per capita increases (Table II.2).

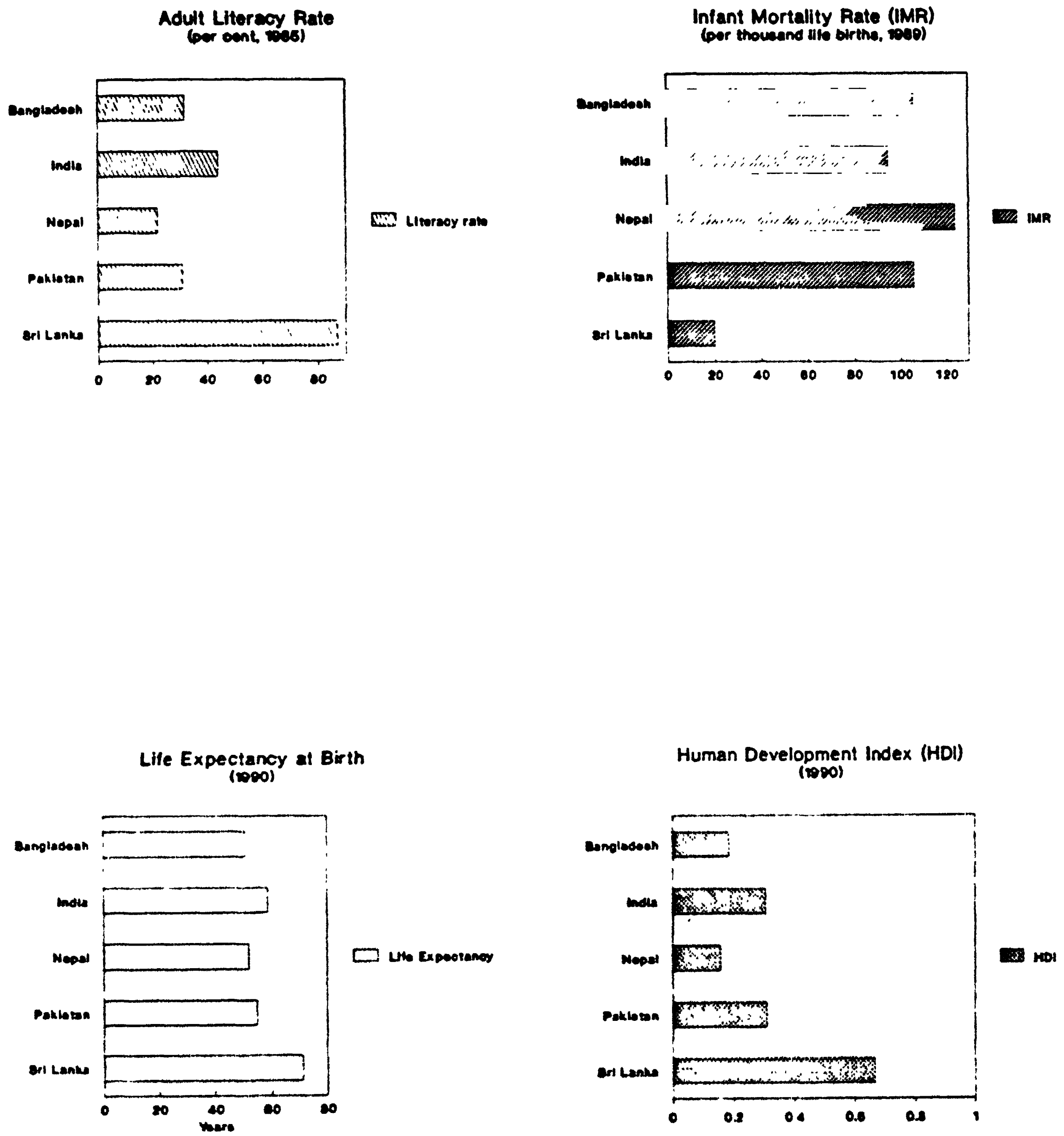
**Table II.2**: Growth of GDP and GDP per capita in the 1980s

| Country | GDP (% per annum) | GDP per capita (% per annum) |
|---|---|---|
| Bangladesh | 4.1 | 1.6 |
| India | 5.3 | 3.0 |
| Nepal | 4.5 | |
| Pakistan | 6.2 | 3.1 |
| Sri Lanka | 3.8 | 2.7 |

Source: Country sources.

[13] Human Development Report (UNDP, 1991) classifies countries into (1) High human development (2) Medium human development and (3) Low human development, according to a Human Development Index.

# Figure 1: Human Development Indicators



The high rates of population growth continue to pose major developmental problems for these economies. With the current demographic features, the South Asian countries are unlikely to reach the hypothetical stationary population levels even in 2025. In Pakistan and Nepal, the growth rates in the 1980s were actually higher than those in the 1965-80 period. At present rates of increase Nepal will add 19 million people by 2025, which is more than Sri Lanka's present population. In India, the magnitude of the population problem can be judged from the fact that at the current rate of increase nearly 17 million people are added every year (Table II.3).

**Table II.3**: Population Growth.

| | Mid-1990 (millions) | Growth Rates (% p.a.) 1980-90 | 1989-2000 |
|---|---|---|---|
| Bangladesh | 106.7 | 2.3 | 1.8 |
| India | 849.5 | 2.1 | 1.7 |
| Nepal | 18.9 | 2.6 | 2.5 |
| Pakistan | 112.4 | 3.1 | 2.7 |
| Sri Lanka | 17.0 | 1.4 | 1.1 |

Source: **World Development Report, 1992**.

The relative importance of these countries in the region in terms of the sizes of their economies, populations and geographical spread may be seen in Table II.4. It is apparent that India dominates on all these counts and, therefore, any study which examines the economic relationship of South Asia with other regions or blocks will inevitably tend to place emphasis on the developments occurring in India.

**Table II.4**: Relative importance of different economies in the region

| | Regional Totals | Country Shares (%) | | | | |
|---|---|---|---|---|---|---|
| | | Bangladesh | India | Nepal | Pakistan | Sri Lanka |
| GDP (US$) | 323060 | 7 | 79 | 1 | 11 | 2 |
| Population (million) | 1104.5 | 10 | 77 | 2 | 10 | 2 |
| Area ('000 sqkm) | 4435 | 3 | 74 | 3 | 18 | 1 |
| CEC * (mtoe) | 202 | 3 | 83 | neg | 13 | 1 |

Source: Compiled from WDR, 1992.
* Commercial energy consumption

In terms of their structure, the economies of this region are still quite heavily dependent on the agricultural sector even though its share has been falling. In Nepal, agriculture is the predominant sector accounting for about 60% of the GDP. In the other countries, the services sector dominates, while the industrial sector shares, other than in Sri Lanka, are less than 30% in all countries (Table II.5)

| Table II.5: Sectoral Share of GDP (%) | | | | | | |
|---|---|---|---|---|---|---|
| | Agriculture | | Industry | | Service | |
| | 1980 | 1990 | 1980 | 1990 | 1980 | 1990 |
| Bangladesh | 49.4 | 37.6 | 14.8 | 17.2 | 35.8 | 45.2 |
| India | 38.0 | 31.4 | 25.9 | 29.2 | 36.1 | 39.4 |
| Nepal | 61.8 | 58.6 | 11.9 | 13.6 | 26.3 | 27.8 |
| Pakistan | 30.6 | 25.8 | 25.6 | 25.5 | 43.8 | 48.7 |
| Sri Lanka | 26.5 | 20.7 | 27.4 | 30.5 | 46.1 | 48.9 |
| Source: **World Development Report 1992**. | | | | | | |

The manufacturing sector, which is the most dynamic part of the industrial sector, has been buoyant in the 1980s in India, Pakistan and Sri Lanka recording growth rates of 7.1%, 7.7% and 6.3% respectively. It may be noted, however, that these growth rates are lower than those recorded in the Newly Industrializing Countries of South-East Asia such as Korea (12.7%) and Thailand (9%).

The industrial sector in these countries have until recently been very highly regulated through elaborate licensing systems and physical controls. This regime is gradually giving way to one which gives greater play to market forces. In addition, it is being increasingly felt in influential policy circles that the public sector should play a smaller role in the future developmental process. Policy initiatives encouraging the private sector (both domestic and foreign) to invest in areas hitherto reserved for the public sector have already been announced in most of these countries.

A disconcerting trend witnessed in these South Asian countries during the last decade was the rapid accumulation of external debt. In order to sustain rates of investment and economic growth in excess of those that could be supported by domestic savings and foreign exchange earned through exports, these countries relied on external sources of finance, both commercial and concessional. Table II.6 shows that external debt as a proportion of GNP and debt servicing as a percentage of export earnings rose quite substantially in all the countries over the last decade.

| **Table II.6**: External debt indicators. | | | | |
|---|---|---|---|---|
| | External Debt as % of GNP | | Debt Servicing as % of Total Exports | |
| | 1980 | 1990 | 1980 | 1990 |
| Bangladesh | 31.3 | 53.8 | 23.2 | 25.4 |
| India | 11.9 | 25.0 | 9.3 | 28.8 |
| Nepal | 10.4 | 53.0 | 3.2 | 18.2 |
| Pakistan | 42.4 | 52.1 | 17.9 | 22.8 |
| Sri Lanka | 46.1 | 73.2 | 12.0 | 13.8 |
| Source: WDR, **1992**. | | | | |

This imbalance in the external sector cast doubts on the sustainability of the growth process, a situation which was further compounded by the Gulf crisis of 1990-91. In the latter half of the seventies and the early eighties, a period when the oil revenues of the Gulf economies were booming, a large number of South Asians found lucrative job opportunities in West Asia. The remittances from these expatriate workers bolstered the current account of balance of payments in these countries. This flow of remittances came to a sudden halt with the disruption caused by the Iraqi invasion of Kuwait. Even though the post-war reconstruction process has begun these flows have not reached the earlier levels.

With rising external debts and terms for future loans becoming stiffer, the South Asian countries are in the process of modifying their industrial policy regimes in order to attract direct foreign investment. The opening up of the oil and gas sectors in India and Pakistan to private foreign investment is an example of this trend.

**Energy Economy Interactions**

The per capita consumption of commercial energy in the region, though rising, is lower than the average of 330 kgoe for the group of low income countries, much lower than the world average of 1200 kgoe, and insignificant in comparison with 5000 kgoe for the high income countries (Table II.7). Even among the South Asian countries there are wide divergences - Nepal uses only 19 kgoe of commercial energy per capita, while the level for Pakistan is 230 kgoe. These low levels of commercial energy consumption per capita are both a cause and consequence of the low levels of economic development in the region.

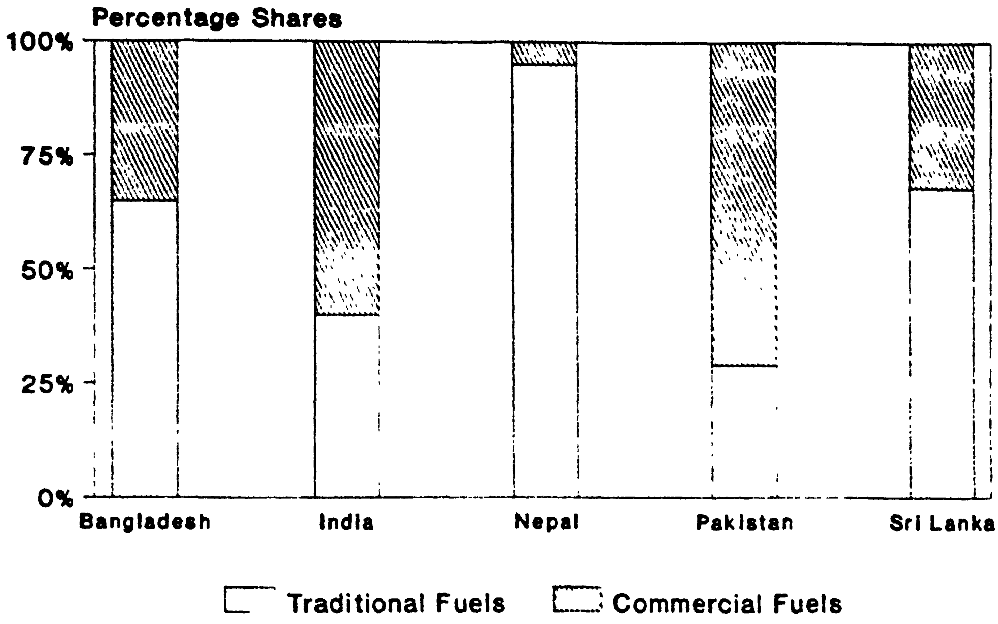
**Table II.7**: Per capita commercial energy consumption (kgoe)

| | |
|---|---|
| Bangladesh | 52 |
| India | 202 |
| Nepal | 19 |
| Pakistan | 230 |
| Sri Lanka | 116 |
| World Average | 1222 |

Source: Country Sources.

The small amount of commercial energy consumed per capita results in a situation where a large part of the energy needs of the populations are met through traditional sources of energy, namely, fuelwood and animal and crop wastes (Figure 2). These sources are often called non-commercial sources since they are mostly gathered rather than bought in markets. Most of the traditional fuels are consumed in rural and low income urban households.

**Figure 2: Shares of Traditional and Commercial Fuels in Primary Energy**



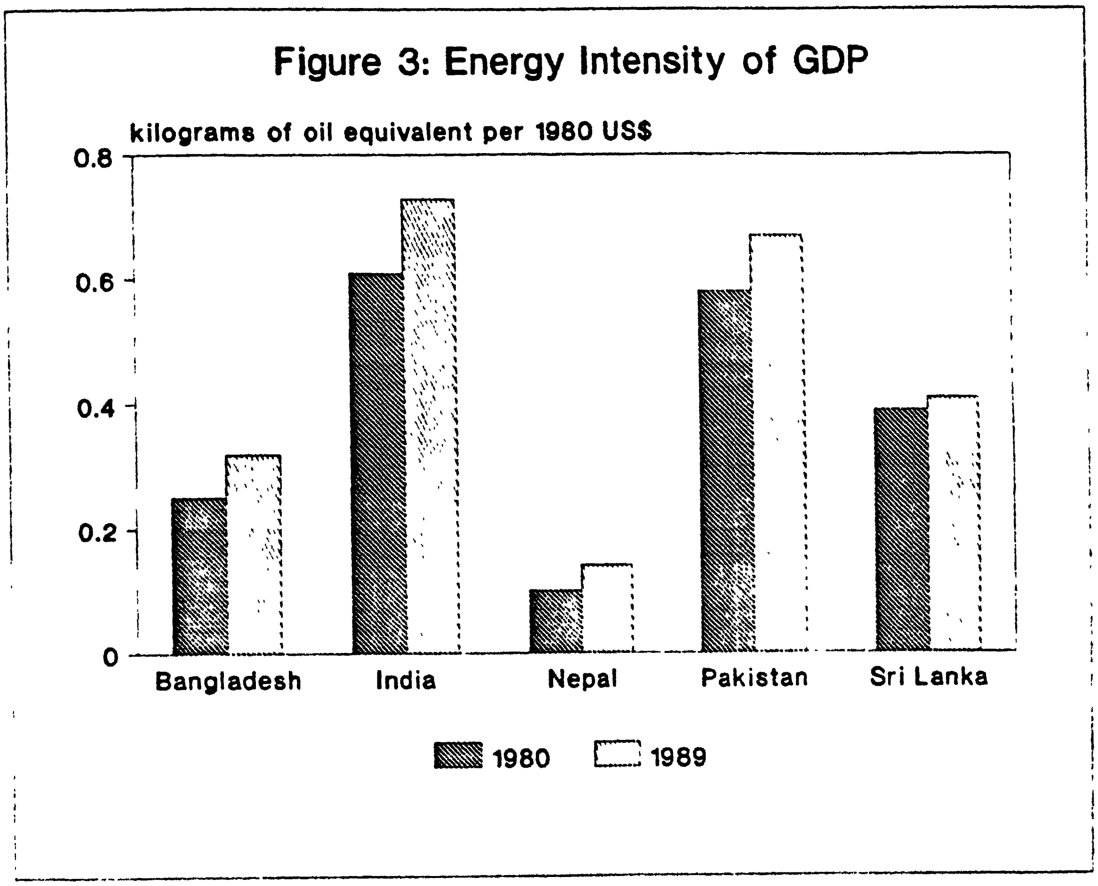

With rising incomes and urbanization the share of these traditional sources has been declining, and this trend is expected to continue in the future. Correspondingly, commercial energy consumption has been increasing at fairly rapid rates. These rates reflect to an extent the economic growth and the accompanying structural shifts that have taken place in the economy. Primary commercial energy availability grew at rates exceeding 6.5% per annum during the 1980s in most countries of the region (Table II.8). The low rate of growth in Sri Lanka largely reflects a weak economic performance.

**Table II.8**: Primary Commercial Energy Availability

| | Energy Availability (1989-90) (mtoe) | Growth in 1980s (% p.a.) |
|---|---|---|
| Bangladesh | 5.78 | 7.2 |
| India | 168.2 | 6.5 |
| Nepal | 0.341 | 7.9 |
| Pakistan | 25.3 | 7.6 |
| Sri Lanka | 1.94 | 2.0 |

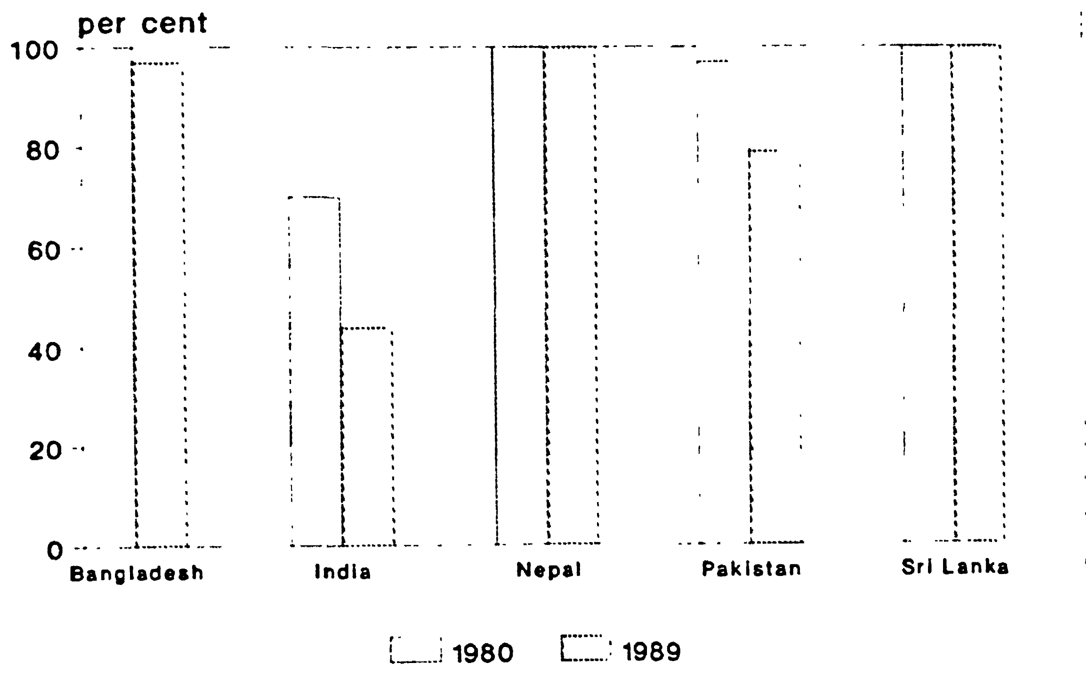
Source: Country Sources.

The commercial energy intensity, defined as the amount of energy consumed per unit of GDP, has risen in all the countries (Fig.3). This reflects growing industrialization and urbanization and the concomitant replacement of traditional energy forms by modern forms. In comparison with the developed countries, these intensities are higher reflecting the inefficient energy utilization and wastage.



Countries of the region are unable to meet their current energy requirements, mainly of oil, through indigenous resources and, therefore, rely on imports. This dependence on oil imports has made them vulnerable to the vagaries of the international oil markets. Efforts at reducing this dependence through enhancing domestic oil production and substituting oil by other indigenously available energy resources have met with some success as Figure 4 highlights. Despite these successes, however, the foreign exchange outgo on account of oil imports continues to consume a large chunk of the export earnings. The next section details the supply and consumption of various energy sources.

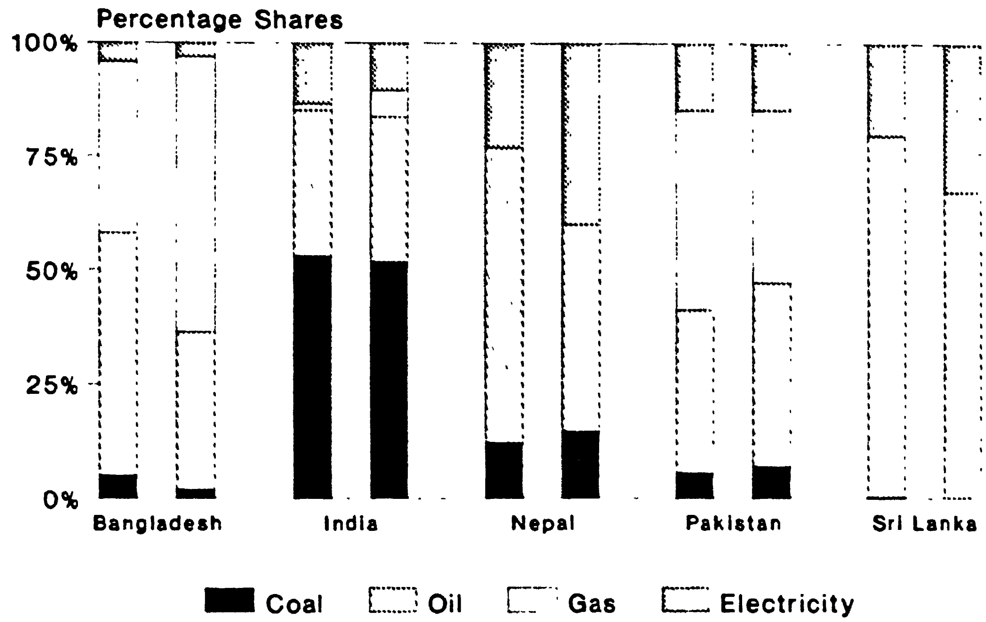
Figure 4: Dependence on Imported Oil



## Section III: Energy Resources, Supply and Consumption

This section examines the relative importance of international price movements and indigenous resource availability in determining the pattern of energy supply in the region. The shares of different fuels in primary commercial energy supply are shown in Figure 5.

Figure 5: Fuelwise Primary Commercial Energy Supply in 1980 and 1989




### Coal

| Table III.1: Coal (including Lignite) Reserves | | |
|---|---|---|
| | Proven Reserves (million tonnes) | Current Production (million tonnes) |
| Bangladesh | 1800 | - |
| India | 61900 | 224 |
| Pakistan | 522 | 2.4 |
| Source: Country data. | | |

More than 97 per cent of the region's coal reserves are located in India. With a proven reserve level of 62 billion tonnes India holds about 5% of the world coal. Coal deposits occur in 44 major fields most of which are concentrated in the eastern part of the country. The uneven distribution of coalfields necessitates the transportation of coal over large distances in order to supply the consumption centres.

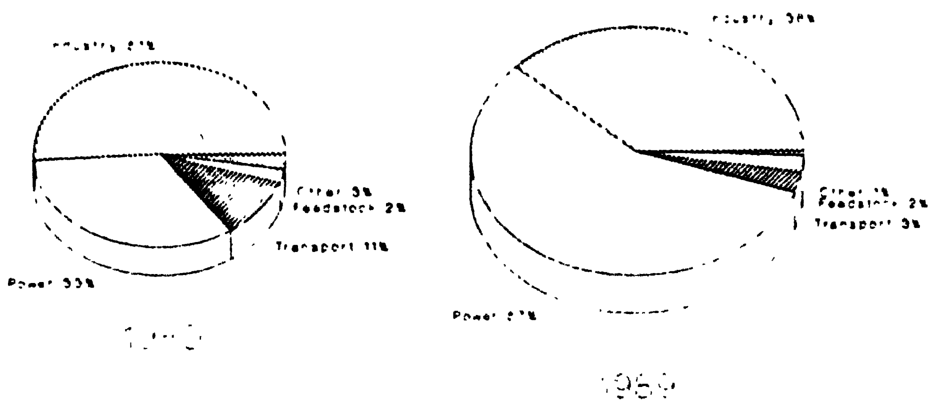
Since the early seventies, coal production has almost doubled to reach a current level of 224 mmt. Though its share in primary commercial energy supply has reduced to some extent, it is still responsible for more than half of supply. The quality of the coal supplied has, however, been declining in recent years and this is causing concern.

Coal production in Pakistan, in the pre 1973 period was on the decline. With the spurt in oil prices, domestic coal production was encouraged and since 1980 coal production grew at 6% p.a. However, with demand outstripping supply, coal imports have risen almost tenfold to a level of 0.9 mt (Table III.1).

In Bangladesh, coal resources have been discovered in the Western region. Total resources are estimated at 1.8 billion tonnes, but a large part of these lie under fertile agricultural lands or water. The economic viability of their extraction is, therefore, a problem. Commercial production has not begun as yet and requirements are met through imports.

Sri Lanka and Nepal rely entirely on imports. Figure 6 below provides sectoral consumption of coal in India.

Figure 6: Sectorwise Consumption of Coal in India



**Oil**

| Table III.2: Oil Reserves | | |
|---|---|---|
| | Proven Reserves (million tonnes) | Current Production (million tonnes) |
| Bangladesh | 5.6 | 0.07 |
| India | 757 | 33 |
| Pakistan | 30 | 3.2 |
| Source: Country data. | | |

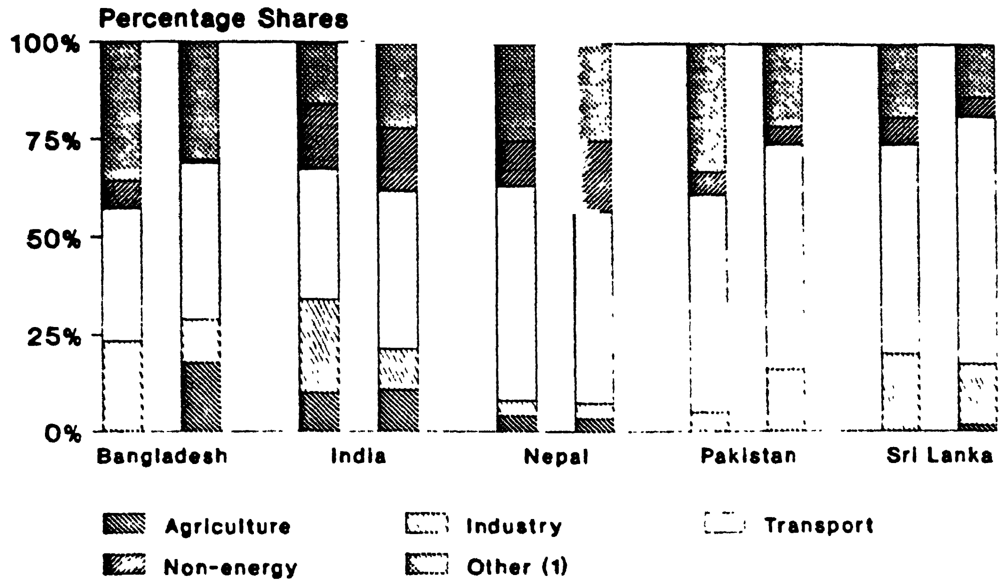
The total area of sedimentary basins in India is about 1.72 million sq.km of which 1.4 million sq.km are on land and the remaining offshore. Of the 26 sedimentary basins only 13 are of interest geologically. The prognosticated reserves in these basins are about 20 billion tonnes of oil and oil equivalent of gas. Compared to these rather large prognostications, the proven and (balance) recoverable reserves is only about 757 mt of oil and 686 bcm of gas (Table III.2).

During the 1980s crude production in India tripled as a result of the development of Bombay High and consequently, dependence on oil imports fell dramatically from 69% to 41%.

In 1989-90, crude oil production of 2.3 mt in Pakistan was almost five times that in 1980 and import dependence fell from 90% to 78%. Pakistan's total oil reserves estimated at 30 mt are concentrated mainly in the northern part of the country. The total sedimentary basin of 800,000 sq km remains largely unexplored. Recent policy initiatives seek to correct this situation. The Petroleum Policy announced in November, 1991 sees a big role for foreign private investment in the future development of its oil and gas sectors and accordingly offers attractive packages to foreign investors.

In all the countries the major consumer of oil is the road transport sector followed by the household sector where oil products are used for cooking and lighting purposes. In the industrial sector oil is consumed both as fuel and feedstock, with the former use dominating in most countries (Figure 7)

## Figure 7: Sectoral Consumption of Oil Products in 1980 and 1989




(1) Res., Comm. and Pub. Services

### Natural Gas

**Table III.3**: Natural Gas Reserves

| | Proven Reserves (bcm) | Current (1989-90) Production (bcm) |
|---|---|---|
| Bangladesh | 382 | 4.7 |
| India | 686 | 18.0 |
| Pakistan | 708 | 14.8 |

Source: Country data.

Natural gas is not only Bangladesh's most important energy source but also its chief natural resource. The deposits are, however, unevenly distributed. The river Jamuna divides Bangladesh into two zones - the Eastern and the Western zones. The gas reserves are concentrated entirely on the eastern side. Fifteen gas fields, fourteen onshore and one offshore, have been discovered with total reserves of 382 bcm.

Gas production grew at 13% per annum in the 1980s and the share of gas in primary energy supply increased from 37% to a current level of nearly 60%. The country was thus able to considerably reduce its dependence on imported oil.

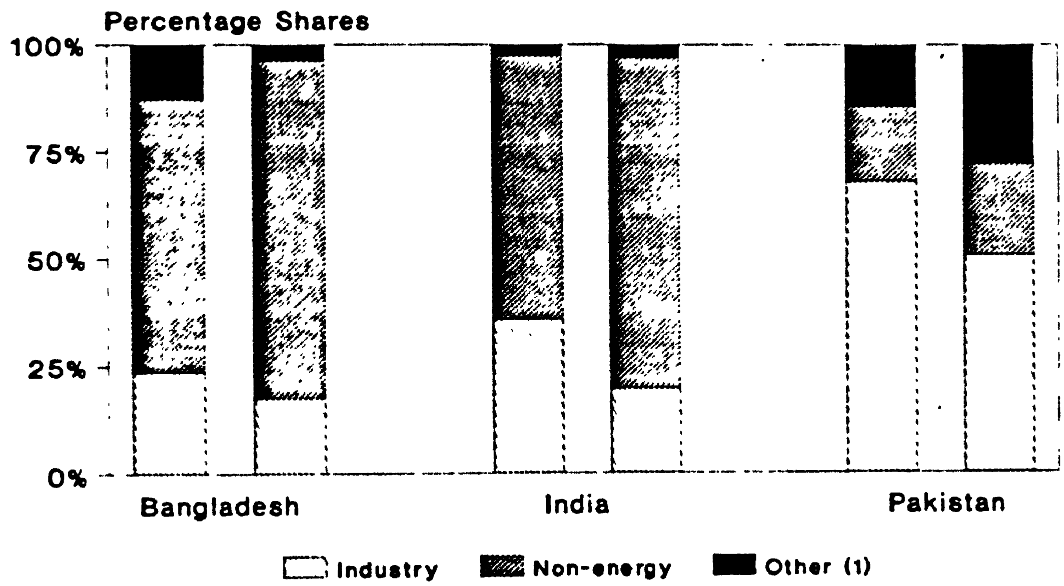
The natural gas reserves of Pakistan are about 708 bcm. Gas has displaced oil in Pakistan's energy sector as well, with the oil share in primary energy supply declining from about 40% in the early

seventies to a present level of around 30%. In recent years, growth in gas production has been stagnating as a result of inadequate planning for gas development in the past (Table III.3).

Natural gas is a relatively new entrant in India's energy sector. Reserves of this fuel are estimated to be 686 bcm. Before the discovery of free gas fields in South Bassein, production of gas was largely in the form of "associated gas". Oil companies paid little attention to its use or to the development of markets. As a result, until the mid-seventies almost 50% of the gas produced was flared.

The oil shocks led to increasing pressures to develop natural gas. Initially, gas was reserved for 'priority' uses, namely as feedstock for fertilizer and petrochemical industries as it was felt that gas generated maximum economic value in these areas. This approach, however, failed to take into account the possibility of higher gas-oil ratios, and paid little attention to infrastructure and market development. All this has led to a situation where nearly 30% of the natural gas produced is still being flared. Thus of the 18 bcm produced in 1990-91 only 12.8 bcm was available for consumption (Figure 8).

Figure 8: Sectoral Consumption of Natural Gas in 1980 and 1989




(1) Resl., Comm. and Pub. Services

## Electricity

The only significant source of commercial energy in Sri Lanka and Nepal is hydropower. Hence, with the oil price increases the primary emphasis in the energy sector especially in Sri Lanka, has been the development of hydropower. During the 1980s installed capacity of electric utilities in Sri Lanka increased from 542 MW to 1241 MW of which 85% was hydro and the rest was oil based thermal power The present hydro share of installed capacity is 78%, while in 1980 the share was 69%.

| Table III.4: Hydropower Potential | | |
|---|---|---|
| | Potential (MW) | Current Capacity |
| Bangladesh | 1300-1500 | 2330 |
| India | 93,000 | 18,440 |
| Nepal | 83,000 | 232 |
| Pakistan | 27,000 | 2,901 |
| Sri Lanka | 1300-2000 | 968 |
| Source: Country data. | | |

Hydropower potential for the region is given in Table III.4. In Nepal, hydropower supplies almost 90% of the electricity requirements from both an interconnected system as well as from remote installations. Their current capacities are 232 MW and 16 MW respectively which is less than 1% of the economically exploitable potential of 42,000 MW. In order to exploit this immense potential, which is far in excess of domestic requirements, Nepal is planning to enter into a power export arrangement with India. The progress of this arrangement has, however, been hindered by differences between the two countries on the pricing formula to be adopted.

Pakistan largely relies on a mix of hydro and gas based generation in order to meet the demand for electricity. In 1980, total installed capacity was 3495 MW of which about half was gas and oil based, and about 45% was hydro based. In 1990, the total capacity had increased to 7777 MW with the gas and oil share rising to 61% and the hydro share falling to 37%. In addition, coal based power capacity was 15 MW and nuclear capacity 137 MW. In terms of generation, though, the shares of oil and gas and hydro were roughly equal. While in the seventies and early eighties the use of gas was encouraged in power stations in place of oil, in recent years oil based generation has grown at nearly 13% per annum largely due to gas shortages.

Owing to its flat topography, the hydropower potential of Bangladesh is only about 1500 Gwh per annum. In 1990, of the 7700 Gwh of electricity generated about 920 Gwh was from five hydro units at Kaptai (in the eastern zone) with an installed capacity of 230 MW. The eastern zone mainly has gas based capacity while in the western zone power is generated exclusively from imported fuel oil. The total oil and gas capacity stood at 2370 MW in 1990.

Unlike other countries in the region, India relies mainly on coal based thermal electricity. More than 50% of the coal produced in the country is used for power generation and about 70% of the installed capacity of electric utilities of 64820 MW is coal (and lignite) based (Table III.5). Hydro based capacity is 18440 MW, while oil and gas and nuclear contributions are 5200 MW and 1565 MW respectively. Between 1980 and 1990 total installed capacity more than doubled. Whereas the thermal share increased from 58% to 70%, the hydro share fell from 39% to 28%. In terms of generation the fall in the hydro share was even more - from 42% to about 27%. The chief reasons for the slower development of hydropower are the long gestation periods of such plants and interstate water disputes.

**Table III.5: Installed Generating Capacities in Power Utilities (1989-90).**

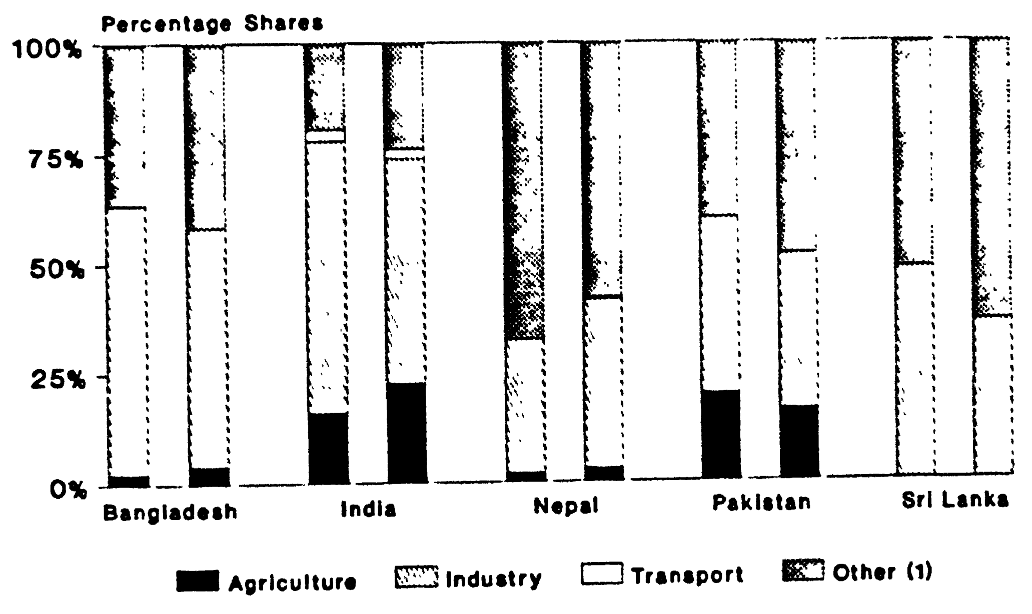
(MW)

| | Bangladesh | India | Nepal | Pakistan | Sri Lanka |
|---|---|---|---|---|---|
| Coal | - | 39615 | - | 15 | - |
| Oil & Gas | 2370 | 5200 | 29 | 4724 | 272 |
| Nuclear | - | 1565 | - | 137 | - |
| Hydro | 230 | 18440 | 232 | 2901 | 968 |
| Total | 2600 | 64820 | 261 | 7777 | - |

Source: Country data.

The consumption of electricity has grown at rates exceeding 10% per annum in Bangladesh, Nepal and Pakistan. In Sri Lanka and India the growth rates were 6.1% and 8.8% respectively. The major demand sectors were the household and commercial sectors. The share of these two sectors in total electricity demand increased in all countries except Nepal an increase that can be attributed to rising household incomes and the spread of electricity in rural areas. The share of the industrial sector went down in most countries while the agricultural share rose. In India and Nepal consumption in the agricultural sector grew at 13.10% to 18% respectively (Figure 9).

Figure 9: Sectoral Consumption of Electricity in 1980 and 1989




(1) Res., Comm. and Pub. Services

## SECTION IV: Trends and Projections of Sectoral Energy Consumption: 'Base Case Scenarios'

This chapter examines the sector-wise trends in energy consumption in selected South Asian countries and the likely future consumption patterns. 'Base Case' (business as usual) scenarios are discussed for three of the countries - India, Pakistan and Bangladesh.[14] In the next section, a set of 'Gas Push' scenarios are developed where the extent to which natural gas can substitute other fuels (especially oil) in the various sectors of the economy are analyzed, assuming that there are no constraints on its availability, i.e. it can be imported in case of indigenous non-availability.

### The Transport Sector

The major market for liquid fuels in the South Asian economies emanates from the transport sector. The demand for the services provided by the transport sector is likely to grow at rapid rates as the trend towards industrialization and urbanization intensifies in these countries.

The share of oil consumed in the transport sector as a percentage of total oil consumption varies between 40% in Bangladesh and India to over 60% in Sri Lanka (Table IV.1). Moreover, except in Nepal this share has risen during the 1980s. The rates of growth in Pakistan and India were 6.9% and 7.6% respectively, whereas in Nepal it was close to 5% p.a. over the last decade.

The transport sector in these countries is dominated by road transport; only in India is rail a significant mode. In road transport diesel is more important than petrol as fuel. The use of other fuels - coal and electricity - in the transport sector is minimal in all countries other than India where they are used in rail transport. Even in India, though, the share of coal is declining as steam locomotives are being slowly phased out.

**Table IV.1**: Shares of different fuels in the Transport Sector

| | Bangladesh | India | Nepal | Pakistan | Sri Lanka |
|---|---|---|---|---|---|
| Coal | 1 | 10 | 1 | - | 0.2 |
| Oil | 99<br>(73) | 88<br>(76) | 98.9<br>(68) | 99.9<br>(70) | 99.8<br>(68) |
| Electricity | - | 2 | 0.1 | 0.1 | - |

Source: Country data.
Figures in parentheses represent the share of diesel in the oil consumed in the transport sector.

The Road Transport Sector

Another feature of private automobiles is that road space occupied by them is far greater than buses. An increase in their numbers thus adds to road congestion and this in turn reduces their fuel efficiency.Mechanized passenger road transport is provided by a wide range of modes including

[14] Analysis of future energy growth paths has drawn on the following studies:
1) "Sectoral Energy Demand in India" (1991).
2) "Energy Demand in the Developing Countries - Prospects for the Future", World Bank Staff Commodity Working Paper No. 23 (1990).
3) "Report of the Energy Task Force on Energy Development and Planning in Bangladesh", Planning Commission, 1991.

mopeds, motorcycles, private cars and buses. With rising incomes, private ownership of motorized vehicles tends to rise; especially when the public transport system is not comfortable or is poorly developed as is the case in the region.

With an increase in personalized modes of transport relative to the public modes, the specific energy consumption of the transport sector tends to rise, other things remaining equal as for example, automobiles typically consume two to three times more energy per passenger kilometre than buses at reasonable levels of capacity utilization. (Table IV.2)

**Table IV.2**: Energy Intensity of Various Transport Modes

| MODE | OCCUPANCY | INTENSITY |
|---|---|---|
| A. PASSENGER TRANSPORT * | | |
| Urban bus | | |
| Regional bus | 50 | 4.5 |
| Motor car | 50 | 4.1 |
| 2 - Wheeler | 2 | 29.5 |
| Diesel train | 1 | 15.4 |
| | 900 | 3.3 |
| B. FREIGHT TRANSPORT ** | | |
| | | 39.2 |
| Diesel truck | - | 4.1 |
| Diesel Train | - | |

* Intensity in toe/million passenger-km
** Intensity in toe/million tonne - km
Source: GOI, **Report of the National Transport Policy Committee 1980.**

In India, Pakistan and Bangladesh personalized transport has been gaining favour while in Sri Lanka and Nepal the share of public buses has been on the rise. In terms of numbers, though, cars and two wheelers have been growing rapidly in all countries

Therefore, in order to reduce the oil intensity of transport, it is desirable that the share of public transport is increased. In some urban centres steps have been taken in this direction and these have met with limited success. However, any major shift towards public modes is unlikely to occur in the next 10-15 years as this would require the construction of mass rapid transit systems, which apart from being highly capital intensive, would take a long time to build.

Given that the population of two wheelers and cars is expected to grow rapidly it is pertinent to look at their efficiencies. In comparison with the vehicles found in the industrialized countries, fuel efficiencies of the ones used in the South Asian countries are lower. Their designs tend to emphasize sturdiness and dependability under adverse conditions (poor roads, little maintenance) over efficiency. Further, the scrappage rates in these countries are low due to the high replacement costs of vehicles. Therefore, the current fleet of vehicles is likely to remain on the road for some time to come. In other words the choice of vehicle made today will have a lasting impact.

At the same time, however, the trend towards more efficient vehicles has begun. A clear example of this is India's Maruti car, built in collaboration with Suzuki, which has a fuel efficiency 1.5-2

times that of the cars produced by older companies. The newer cars and motorcycles in other countries also show improvements in the fuel they consume per kilometre travelled. This trend is likely to persist and may infact be speeded up by environmental concerns.

The possibility of an "efficiency rebound" - that more efficient vehicles tend to be used more - cannot be ignored and as a consequence the fuel consumed by newer cars may turn out to be more than the older ones.

The Rail Transport Sector

Railways as a mode of transport is very important in India and to some extent in Pakistan. In the other countries rail transport is poorly developed. A disturbing trend that has been witnessed in India and to a lesser extent in Pakistan, has been the continuing shift away from railways towards more energy (oil)-intensive road transport. In India, railways have lost its share in both freight and passenger traffic. In total freight traffic the rail share has fallen from about 60% in 1975 to a current level of 40%, while its share of passenger traffic went down from 26% to 20% over the same period. Similar trends may be discerned in Bangladesh, but more important is the declining role of river transport vis-a-vis road transport. River transport is even less energy intensive than rail.

Within railways, electrification of tracks is an important priority in both India and Pakistan, in order to replace diesel traction. In Nepal, the use of electricity in transport in the form of urban trolley buses and ropeways can go a long way in substituting an imported fuel with an indigenously available one.

In general, the possibilities of fuel substitution are limited and oil will remain the mainstay. Consumption will rise at a fast pace given the expected growth in traffic volumes, and will probably accelerate, in the next 10 years. As pointed out earlier, investments in energy efficient modes will not only require huge amounts of capital but will also take time to build. In addition, people will require some time in order to make behaviourial changes in the way they travel. After 2000 A.D., the growth rate will decline somewhat because investments in energy efficient modes would begin to take shape and people would probably have made some behaviourial adjustments. Moreover, private vehicle ownership rates would have moved to levels where they would be growing more slowly than at present.

Thus, according to the studies mentioned earlier, oil consumption which grew at 7% p.a. in the 80s in Pakistan will rise to 9.2% in the 90s and then slow down to 7.4% between 2000 and 2010. In India the growth rates for the corresponding periods are likely to be 8.5% and 5.7% (Table IV.3).

**Table IV.3:** Oil consumption in the transport sector

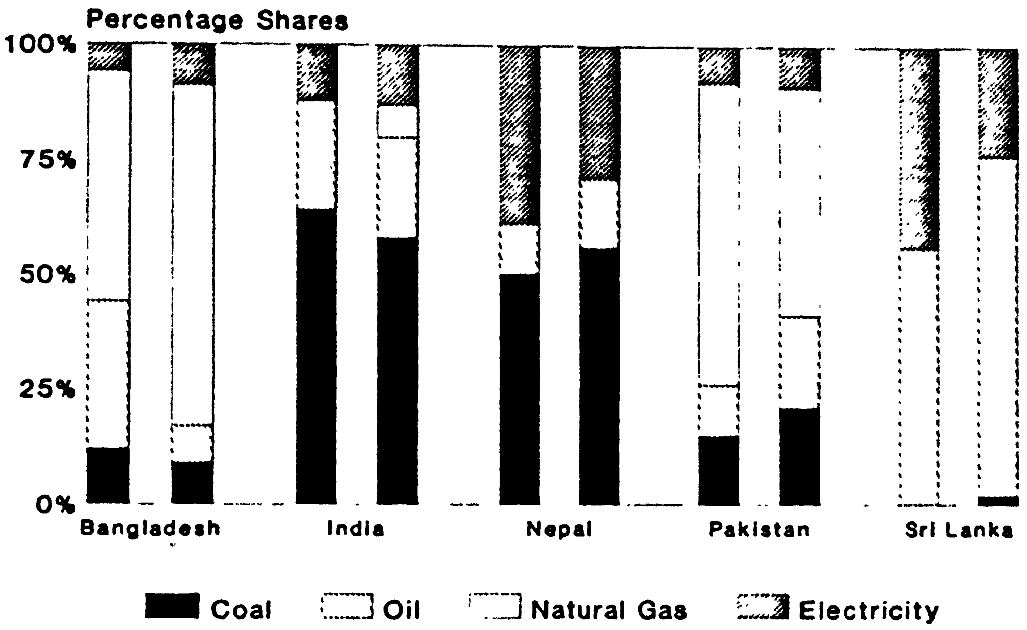
| | Consumption | | Growth rate | |
|---|---|---|---|---|
| | 2000 | 2010 | 1989-2000 | 2000-10 |
| Pakistan | 11.0 (52%) | 22.4 (62%) | 9.2% | 7.4% |
| India | 49.7 (50%) | 86.0 (55%) | 8.5% | 5.6% |
| Bangladesh | 1.15 (43%) | 1.91 (53%) | 6.7% | 5.2% |

Fig in parentheses is the oil consumed in the transport sector as % of total oil consumed.
Source: See footnote 14.

**The Industrial Sector**

Coal is the major fuel consumed in the industrial sectors of India and Nepal, while in Pakistan and Bangladesh natural gas dominates. Only in Sri Lanka is oil the chief source of energy (Figure 10).

Figure 10: Fuelwise Shares in Industry (1980 and 1989)




At the time of the first oil shock Pakistan's industrial sector depended heavily on imported oil. During the rest of the seventies oil consumption stagnated, losing its share to natural gas. In the eighties, however, oil consumption grew at a high rate of 21% per annum. This growth was caused by a large scale switch to fuel oil by cement plants and partly due to the relatively higher price of gas and its inadequate supply. In India and Bangladesh the share of oil in the industrial sector fell in the 1980s, the fall being particularly marked in Bangladesh, where the consumption of oil declined in absolute terms as well. India experienced a growth rate of 4% per annum.

The industrial consumption of oil is largely for energy purposes in all countries, except India. Most of the gas in India's and Bangladesh's industrial sector (80-90%) however, finds its way as feedstock in the fertilizer plants. In Pakistan, the opposite holds with about 70% of the gas being consumed for providing energy (Table IV.4).

| **Table IV.4**: Share of Oil and Gas for Energy and Non-energy Purposes (%) | | | | |
|---|---|---|---|---|
| | Oil | | Natural Gas | |
| | Energy | Non-Energy | Energy | Non-Energy |
| Bangladesh | 88 | 12 | 19 | 81 |
| India | 40 | 60 | 10 | 90 |
| Pakistan | 79 | 21 | 70 | 30 |
| Sri Lanka | 76 | 24 | - | - |
| Source: Country data. | | | | |

It is expected that the demand for energy intensive products such as steel, cement, paper, textiles and fertilizers will continue to increase, given their current low per capita levels of consumption. The efficiency with which energy is consumed in these industries leaves much to be desired. Most countries estimate energy savings of at least 10% merely through better housekeeping measures, at low extra cost.

In the coming years, the capital that will be invested at the margin is likely to be more energy efficient than that presently in place. Moreover, energy conservation measures will be pursued with greater vigour and initiatives in this direction are already under way. In Pakistan, the realistic energy potential in industry has been placed at 22% of the total energy demand. ENERCON the National Energy Conservation Centre is working on a four year plan (1989-93) which is estimated to cost US$ 130 million and is expected to result in cumulative energy savings of 3200 ktoe over the period with financial benefits of about US$ 600 million for the entire economy.

The Bangladesh Ministry of Energy with the help of the World Bank has established an Energy Monitoring Unit. A report submitted by it in March 1986 has estimated that approximate investment of US$ 133 million will result in efficiency improvements of 454 ktoe/year with an average pay back period of only 1.6 years It is estimated that in Bangladesh, efficiency in the domestic sector, especially in the biomass and fuelwood is very low and appropriate technologies can result in savings to the tune of 40% of total fuelwood

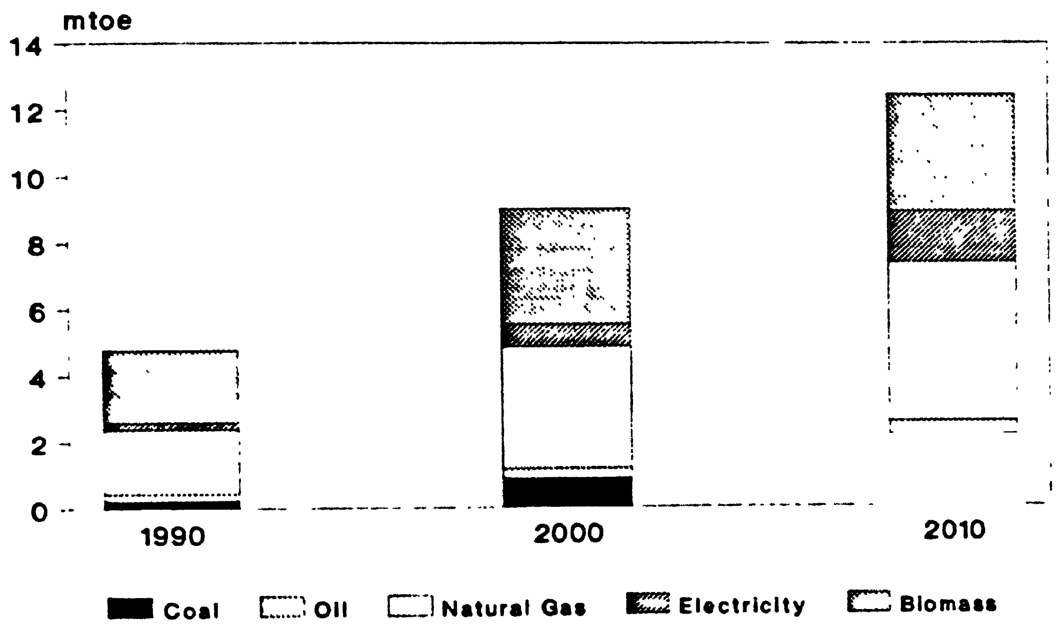
In India, the Inter-ministerial Working Group on Utilisation and Conservation of Energy (1983) carried out in-depth studies of some of industries and estimated a conservation potential of 25%. A survey conducted by the National Association has concluded that on average, 15-20% savings in energy are achievable without any significant investments.

An important feature of industrial energy consumption in Pakistan and India is that only a few very energy intensive industries (steel, cement etc.) account for a large share. This allows policy actions to be targeted on a narrow band of industries with high payoff potential. Energy conservation measures in industry can be grouped into housekeeping and operational improvements, thermal system improvements, electrical system improvements, waste heat recovery, cogeneration and process modification.

These conservation measures and more energy efficient production processes would tend to reduce the energy intensity of industrial production and thus dampen total energy growth rate. In spite of this, due to the expansion of the industrial sector, the consumption of fossil fuels (both as fuel and

feedstock) will continue to grow at fairly high rates until the turn of the century. The impact of new technologies will be felt mainly after the year 2000, though conservation measures will have a quicker (but smaller) impact. Accordingly, fossil fuel consumption in industry will increase at rates ranging from 4.5% p.a. in Pakistan to 8% p.a. in Bangladesh in the period 1990-2000, but would slow down to under 3% and about 4.3% respectively (Table IV.5). Interfuel substitution may also be expected. In Bangladesh, the share of coal is expected to rise substantially and this will replace both oil and biomass. Natural gas consumption will remain high and rising, especially until 2000 (Figure 11).

**Figure 11: Industrial Fuel Consumption in Bangladesh**




In India, coal will continue being the dominant energy source in the industrial sector. Fuel switches will largely depend on whether the government encourages greater use of gas and coal in place of oil. The substitution of fuel oil by natural gas is particularly important in the Western region and along the HBJ pipeline, where gas availability does not pose a problem. In the production of fertilizers, it is very likely that gas will overtake naphtha as feedstock, even in the absence of aggressive substitution policies.

| Table IV.5: Energy Consumption in the Industrial Sector (in mtoe) | | | |
|---|---|---|---|
| | 1989 | 2000 | 2010 |
| Pakistan | 8.21 (19.8%) | 13.7 (21.2%) | 17.8 (22.5%) |
| Bangladesh | 2.33 (8%) | 4.85 (5.4%) | 7.36 (4.5%) |
| India | 63.3 (22.1%) | 99.7 (22.5%) | 160.0 (22.9%) |

Figures in parentheses are the oil shares
Source: See footnote 14.

**The Household Sector**

Households account for 40-45% of total energy use in India and Pakistan, 60% in Sri Lanka, 75% in Bangladesh and over 90% in Nepal. A striking feature of this sector's energy consumption pattern is the predominance of traditional fuels - fuelwood, crop and animal wastes. The consumption of these fuels is more in rural areas than in urban areas and in low to middle income households. Often traditional fuels can be gathered at no financial cost and used in very simple stoves - as simple as an open fire. However, other kinds of costs are associated with the use of traditional fuels - large amounts of labour, time and inconvenience. Working with traditional fuels is also usually unpleasant and unhealthy due to the large amount of noxious smoke emitted (Table IV.6). Measurements of indoor concentrations in homes in developing countries have found levels of carbon monoxide, particulate, and hydrocarbons many times higher than World Health Organization standards. Smoke from cooking stoves is therefore thought to be a significant factor in ill-health in developing countries.

**Table IV.6**: Emission factors for different pollutants from cooking stoves for various fuel-stove combinations. (g/kg)

| Stove type, fuel and pollutant | Conventional Metal | Improved Metal | Improved Mud |
|---|---|---|---|
| **Fuelwood** | | | |
| TSP | 1.3-2.7 | 1.1-3.8 | 1.8-2.1 |
| CO | 13-22 | 25-62 | 32-48 |
| **Crop Residues** | | | |
| TSP | 2.1-5.0 | 2.1-12.0 | 3.5 |
| CO | 20-39 | 23-114 | 48 |
| **Dungcakes** | | | |
| TSP | 4.1-5.3 | 4.2-7.8 | 7.4 |
| Co | 11-16 | 34-67 | 46 |

Source: TERI, **Evaluation of Performance of Cookstoves in Regard to thermal Efficiency and Emissions from Combustion**, February 1987.

The transition to modern stoves and fuels is often sharply constrained due to their higher capital costs and uncertainty in the supply of fuel. In Colombo, Sri Lanka, for example, the cost of converting to LPG in 1983 was equivalent to a month's income for 70 per cent of the population and 5 months' income for the poorest 20 per cent.

As households make the transition from wood to modern fuels, overall energy use for cooking can vary dramatically, depending on the choice of technology and the situation in which it is used. Device efficiencies in the economies can range from 8 - 55% as seen in the table below. Total household energy use for cooking with kerosene or with LPG can be significantly less than that for wood or charcoal, due to the higher efficiency of kerosene and gas stoves. Total household energy use for cooking with kerosene or LPG is also significantly less than for cooking with charcoal or (non-hydro) electricity due to the low conversion efficiency of wood to charcoal and of fuel to electricity.

**Table IV.7**: Cooking Device Efficiencies

| Device Efficiencies | Percent |
|---|---|
| Simple electric stove | 0.50 |
| LPG/natural gas stove | 0.55 |
| Kerosene stove (wick) | 0.40 |
| Charcoal stove | 0.30 |
| Traditional firewood stove | 0.08 |
| Improved firewood stove | 0.20-0.50 |

Source: VVN Kishore, "Cooking Energy System - A Comparative Study" in R.K. Pachauri and L. Srivastava (ed.) Energy Policy Issues. Volume 4 (1989) pp. 37-45, TERI, 1989.

The transition to modern stoves and fuels thus offers users many benefits - reduced time, labour and possibly fuel use for cooking, and reduced local air pollution. Because of the high cost of LPG cooking, kerosene is widely used as an intermediate step in the transition from wood to gas stoves. Kerosene prices are subsidized by the government. Consumers switch between these fuels according to price and availability.

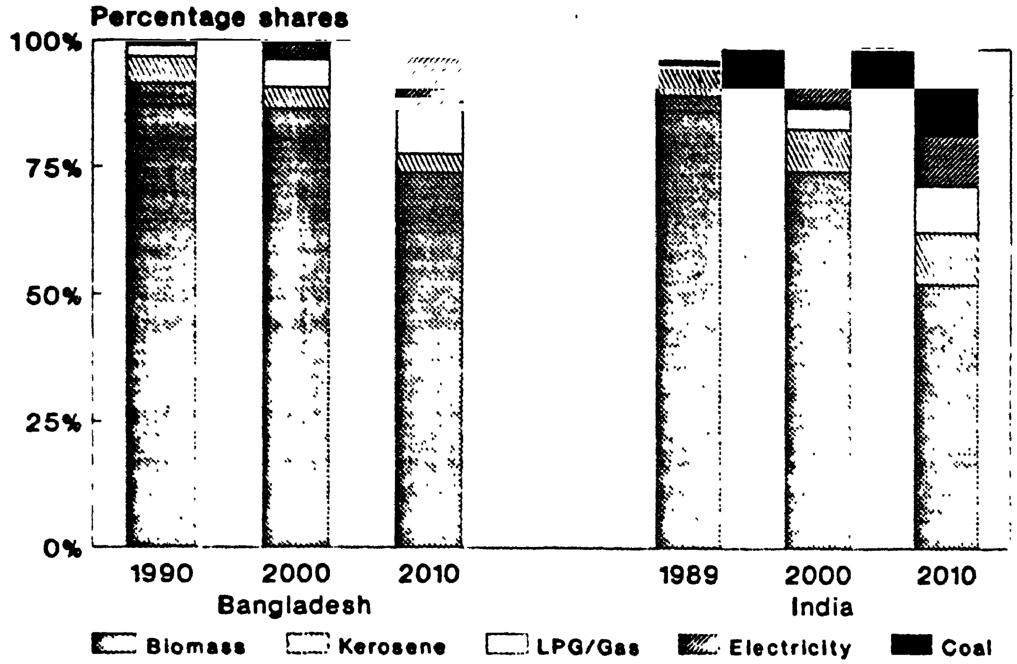
LPG or natural gas is often the final step in the progression in cooking fuels. LPG is widely used by higher income groups in many urban areas, and natural gas is widely used where it is available. In Dhaka, Bangladesh, for example, over 50 per cent of the urban population uses natural gas; less than 10 per cent use kerosene; and none use charcoal. In some cases, electricity is also used for cooking by the highest income groups.

In Bangladesh the share of kerosene is likely to decline from its current level of 5.4% to about 3.8% in 2010. The shares of gas and electricity both rise with the latter being quite marked. The biomass share declines and in absolute terms the consumption of biomass fuels would stagnate after 2000.

The share of kerosene in the household sector of India has risen quite substantially over the last two decades. This increase came about largely as the result of the substitution of coal by kerosene. In the future this trend is likely to be reversed with the government encouraging the use of soft coke in the domestic sector in place of imported kerosene and biofuels. The share of coal is thus seen to rise from about 2% in 1989 to nearly 15% in 2010 and that of kerosene rises marginally to reach about 10%.

While the consumption of biofuels declines in absolute terms that of electricity and LPG rises at rates of nearly 10% per annum between 1989 and 2010 (Figure 12).

Figure 12: Household Energy Transition




**The Agricultural Sector**

In recent years the agricultural sector has emerged as an important demand source for commercial energy. High man to land ratios and the need for increased food production to meet the needs of growing populations have resulted in intensive agriculture involving large inputs of commercial energy. This trend is expected to continue.

Energy conservation in this sector, in the form of better maintenance of pumpsets for instance, can help in reducing the rates of growth of commercial energy use. In India the Petroleum Conservation and Research Association estimates that 30% of the diesel consumed in the agricultural sector can be saved through conservation measures.

To summarize, the base case demand for oil in 2010 is likely to be 30.9 mtoe in Pakistan, 160.8 mtoe in India and 3.60 mtoe in Bangladesh. The sector wise break up for oil and gas demand to 2010 are given in the tables below.

**Table IV.8**: Sector-wise Demand for Oil in 2010 (MTOE)

| Country/Sector | B'Desh | India | Pakistan | Total |
|---|---|---|---|---|
| Transport | 1.91 | 86.0 | 22.4 | 110.31 |
| Industry | 0.40 | 36.6 | 4.0 | 41.00 |
| Residential & Commercial | 0.58 | 32.6 | 4.5 | 37.68 |
| Agriculture | 0.71 | 5.6 | - | 6.31 |
| Total | 3.6 | 160.8 | 30.9 | 195.30 |

**Table IV.9**: Sector-wise demand for gas in 2010 (bcm)

| | Bangladesh | India | Pakistan* |
|---|---|---|---|
| Transport | - | - | |
| Industry(1) | 5.6 | 10.6 | |
| Residential/commercial | 1.6 | 0.28 | |
| Power generation | 15.0 | 27.00 | |
| Total | 22.2 | 37.88 | 25.2 |

(1) Including non-energy use.
* Sectoral break-ups are difficult to obtain.

The import requirement for oil as percent of total oil demand in 2010 is estimated to be as follows:

Bangladesh : 97-100%
India : 55-60%
Pakistan : 42%
Sri Lanka : 100%
Nepal : 100%

Despite measures to conserve oil and to substitute it by other fuels or by indigenous production, it is evident that oil import requirements will remain high. Thus considerations of foreign exchange and security of supply that have influenced policy hitherto will continue to remain of importance. To these concerns are added those of a new environmental consciousness, both internationally and of the domestic polity. It is in this context that a shift to gas as a cleaner fuel relative to other fossil fuels is being advocated. The next section takes up a gas push scenario for detailed discussion.

## Section V: Alternative Scenarios: The Gas Push

The demand scenarios presented so far do not consider the option of importing natural gas. This implies that the demand projections for natural gas have tended to be supply constrained. In this section, gas push scenarios are developed based on the assumption that imports of gas are allowed.

There are four strong arguments for accelerating the gas push in various sectors of the South Asian economies.

(i) As seen in Sections I and III, there is a relatively large resource base of natural gas in Pakistan, India and Bangladesh, and a very large resource base in countries of West and South East Asia

(ii) Natural gas is a versatile product that lends itself to a number of energy and non-energy applications. Gas can be used not only to penetrate existing coal, oil and electricity markets in these economies, but it can create new markets. As a fuel, it can be used for drying and heat treatment at low temperatures. It has been found to be particularly attractive for drying of milk, cereal, malt, textiles, paper and pottery. It can also be used in commercial applications such as shopping complexes, offices and hotels in place of diesel, LPG and fuel oil. In the residential sector it can be used to replace firewood and coal briquettes used for cooking and heating purposes. In its non-energy applications, it can be used to create gas based fertilizers and petrochemicals, products very much in demand and growing in South asian economies. The matrix below summarizes these substitution possibilities.

**Substitution Matrix for Natural Gas**

| Sector | Energy products to be substituted | NG Substitute |
|---|---|---|
| Industry | Fuel oil | NG |
| Fertilizer | Naphtha, Fuel oil | NG |
| Power | Coal | NG |
| Household | Kerosene | LPG from NG/ piped NG |
| | LPG | Piped NG |
| Transport | Diesel, Petrol | CNG |
| Agriculture | Diesel | CNG |

(iii) Technological developments in gas based applications have vastly improved their efficiencies enabling such applications to compete with coal and oil based alternatives. This is specially so in the case of gas based power plants, where conversion efficiencies have increased sufficiently to allow gas to compete with coal for base load generation. World Bank estimates that gas based combined cycle power plants can generate electricity at 25% less cost than coal based power plant equipped with the latest pollution control devices.[15] Technological developments

[15] L. R. Brown et al. State of the World 1992, A Worldwatch Institute Report, W.W.Norton & Co., New York, 1992, p 35.

are also considerable reducing the costs of gas based transportation, i.e., based on CNG or LNG.

(iv) Natural gas has a number of environmental advantages as it emits less carbon monoxide, hydrocarbons and particulates relative to oil and coal. This is significant especially in the context of large metropolitan cities in these economies, in particular those of India, where air quality is severely impaired. Table V.1 below summarizes the air pollutants from various electricity generating technologies. Natural gas also has much lower carbon intensities than coal, oil or synfuels . This fact assumes significance in the context of the concern with fossil fuel generated greenhouse gases that are believed to be contributing to a global warming. Since it is impossible to do without fossil fuels, a case is made for the move toward use of less carbon intensive fossil fuels of which natural gas is a good candidate as it emits 40% less carbon than oil and 75% less than coal. Emissions of carbon from synfuels are about 100-200% larger than that from natural gas. It is estimated that CNG based transportation will reduce GHG emissions by 19% per unit of distance relative to petroleum and LNG based transportation by 15%[16].

**Table V.1**: Air Pollution from various Electricity Generating Technologies

| | Conversion efficiency % | Grams per kWh | | |
|---|---|---|---|---|
| | | $NO_2$ | $SO_2$ | $CO_2$ |
| High sulphur coal fired steam power plant (without scrubbers) | 36 | 4.3 | 21.1 | 889 |
| High sulphur coal fired steam power plant (with scrubbers) | 36 | 4.3 | 2.1 | 889 |
| Low sulphur coal fired fluidized bed plant | 32 | 0.3 | 1.2 | 975 |
| Oil fired steam plant | 33 | 1.4 | 1.6 | 794 |
| IGCCP (coal gasification) | 38 | 0.2 | 0.3 | 747 |
| Gas Turbine CCP | 43 | 0.3 | 0 | 416 |

Source: WWI, **State of the World 1992**, p 36.

Increasing the Market Share of Natural Gas Through Fuel Substitution

This section examines the extent to which South Asian countries of our region can increase the share of natural gas in total energy consumption, relative to the base case scenarios presented earlier.

1. The Transport Sector

In the transport sector natural gas in the form of CNG (compressed natural gas) can substitute both petrol as well as diesel. A vehicle running on petrol can be retrofitted so that it can run on CNG also. Thus, the driver may switch between the two fuels. In the case of diesel, the retrofit allows the vehicle to be driven by a mixture of diesel and CNG, but not either fuel alone. The extent of diesel substitution

[16] Sperling and Deluchi, IEA/OECD Experts Seminar on Energy Technologies for Reducing Emissions of GHGs, OECD, 1989.

varies between 30%-90% depending on the type of vehicle. Vehicles can also be manufactured to run on CNG only - these are called dedicated CNG vehicles.

One of the main attractions of CNG vehicles is their relatively low levels of pollutant emissions. This feature of CNG vehicles assumes great importance in the metropolitan areas of the South Asian countries where pollution levels have already exceeded or will soon exceed the permissible limits.

The major vehicular pollutants are carbon monoxide (CO), oxides of nitrogen ($NO_x$), hydrocarbons (HCs) and oxides of sulphur ($SO_x$). In addition lead is another toxic pollutant associated with the use of petrol and particulate emissions are associated with diesel. The use of natural gas can help in reducing several of these pollutant emissions as Table V.2 indicates.

**Table V.2**: Engine Emissions

| Pollutant | Diesel | Petrol | CNG |
|---|---|---|---|
| Unburned HCs (%) | 0.10 | 0.05 | 0.03 |
| CO (%) | 0.20 | 1.70 | 0.20-0.80 |
| $NO_x$ (%) | 0.25 | 0.50 | * |
| $SO_2$ (%) | 0.03 | 0.008 | neg |
| Aldehydes (%) | 0.002 | 0.003 | none |
| Particulates (g/m$^3$) | 0.25 | 0.05 | none |
| Lead (mg/m$^3$) | none | 50.0 | none |

* $NO_x$ concentrations vary considerably with engine design.
Source: IGIDR, **Compressed Natural Gas (CNG) in Transport Sector: Techno-Economic Assessment for India**, [Discussion paper No. 40, March 1991], P 91.

There is an economic reason as well for using CNG in the road transport sector. A study by TERI[17] estimates that in India the economic cost per unit of transport service supplied is lower for CNG* than for diesel Specifically, it is estimated that the economic cost per '000 tonne-km in road freight transport is $9 when diesel is used and $5.4 when CNG derived from domestically available natural gas is used. For passenger transport the costs are $1 and $0.6 per '000 passenger-km for diesel and CNG respectively. In the case of CNG from imported gas, but are still lower than those for diesel - $5.8 and $0.7 for freight and passenger movement respectively.

CNG programs have already been initiated in the South Asian region. In Pakistan, the CNG program was started in 1981-82 and about 270 vehicles were converted. There are plans to convert 21,000 vehicles to CNG and build 33 refilling stations. In Bangladesh 13 diesel trucks and 16 cars were converted to run on CNG. A national CNG company has been formed in order to commercialize CNG use in cities. A local diesel engine manufacturer has already started producing dedicated natural gas engines for trucks. The ONGC in India has successfully conducted trial runs in Gujarat for 2 buses, while IBP is conducting trial runs on cars and a truck in the north-eastern state of Tripura.

[17] TERI, 1991. Integrated Energy Pricing. The study was conducted at 1987-88 prices.

There are a number of reasons to concentrate on diesel as the immediate target for substitution by CNG:

(i) the present high share of diesel in the transport sector relative to petrol

(ii) the deficit of diesel relative to demand, thereby necessitating imports

(iii) the organizational advantages of replacing diesel as buses and trucks tend to be concentrated in fleets. This implies that each CNG fuelling station will be able to cater to a large number of vehicles, thereby assuring it of a sizable market. The existence of a market, in turn justifies the investment in the fuelling station and the gas pipelines. In the case of petrol, similar investments may not be justified in the near future because of its relatively lower consumption and greater spread of petrol consuming vehicles,

In India, a study by the Indira Gandhi Institute for Development Research gives an indication of the substitution levels that are achievable. The study first estimates the amount of natural gas available domestically to substitute diesel in different regions of the country in the year 2000. This gas availability has been worked out after deducting the gas committed to the power and fertilizer sectors. The diesel requirements in the regions are also worked out. The 'maximum possible' level of diesel substitution by CNG is defined as the minimum of gas availability and diesel requirement. The different substitution scenarios are then drawn up under different assumptions about the fraction of the 'maximum possible' level that may be substituted (Table V.3).

**Table V.3:**

(million tonnes)

| Region | Gas Availability 1999-00 | HSD demand in transport sector 1999-00 | Maximum possible subst'n of HSD | Gas substitution scenarios | | |
|---|---|---|---|---|---|---|
| | | | | *@ 10%* | *@ 20%* | *@ 30%* |
| West & North | 10.85 | 14.53 | 10.79 | 1.07 | 2.14 | 3.21 |
| East & North-East | 12.53 | 3.05 | 3.05 | 0.30 | 0.60 | 0.90 |
| South | 3.49 | 7.59 | 3.49 | 0.50 | 1.00 | 1.50 |
| Grand Total | 26.84 | 25.17 | 17.33 | 1.37 | 3.74 | 5.61 |

Source: IGIDR, **op cit**, p 17.

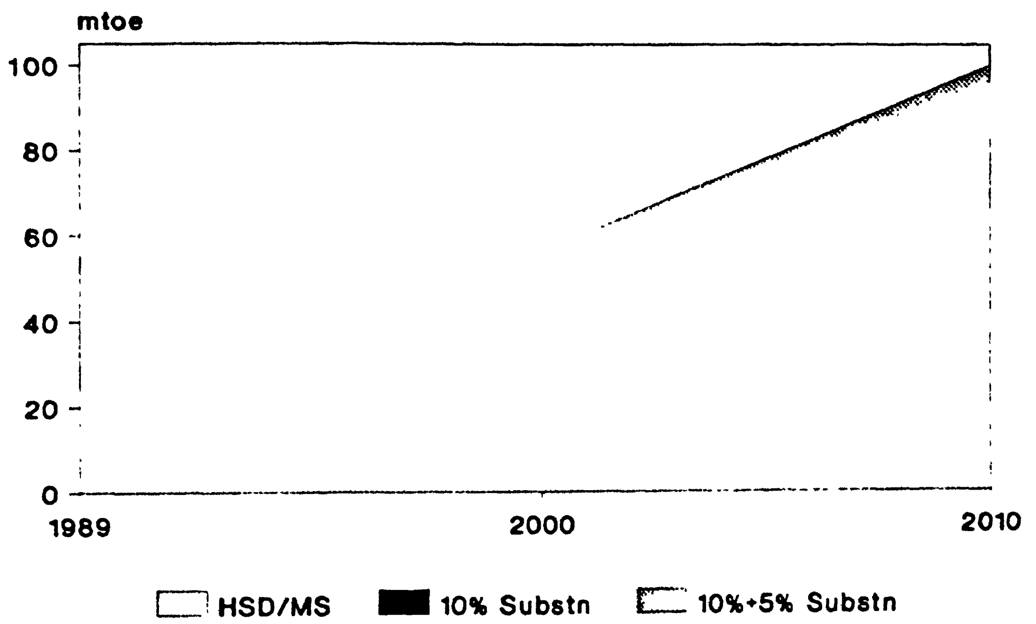
At 10% of the maximum possible level 1.37 mt of diesel can be substituted, which amounts to 5.4% of total diesel consumed in the road transport sector in 2000 A.D. This modest level is considered achievable and would imply a conversion of about 7-9% of the trucks and buses in 2000 A.D. in a 50:50 mode.

Assuming that the modest CNG program of the earlier years had been successful, then by around the year 2005 the reliability of this fuel would be well established. Moreover, a reasonable amount of infrastructure to market CNG would be in place. It would therefore be possible to even introduce dedicated CNG vehicles in the market and by 2010 these too may be well established. Whereas in the earlier phase of CNG development, the thrust would have been on substituting diesel, petrol consumption would now be reaching levels where replacing it by CNG might also be a policy target. Thus the range of substitution in the second phase would be more assuming that gas availability

is not a constraint (i.e imports are allowed). Permitting imports has another implication. In the first phase domestic gas was seen as a replacement for imported oil, but now it would be possible to view *imported* gas as a substitute for *imported* oil.

Given the above considerations we assume higher substitution levels of 10-15% of the oil consumed in the road transport sector in 2010. In gas equivalent terms this amounts to a total of about 11-17 bcm per year, for the three countries together (Figure 13).

Figure 13: Oil Substitution by CNG in Road Transport




**The Household Sector**

In the household sector the use of natural gas as a fuel for cooking is widespread in the urban areas of Pakistan. Pakistan has one of the most well established gas distribution networks among developing countries. Households account for almost 30% of the natural gas consumed in the country. Low gas prices combined with grid extension led to consumption increasing by more than 12% p.a. in the 1980s. Natural gas substituted kerosene to quite an extent as a cooking fuel. This substitution will continue in the future and by 2010 the share of oil products in the commercial energy consumed in households will decline further -- from about 40% at present to about 30%. As seen in Section IV, in Bangladesh too the share of gas in this sector will increase quite appreciably and the oil share will decrease.

The point here is that even in the Base Case the extension of the natural gas distribution network to additional households is quite substantial in both Pakistan and Bangladesh. In Bangladesh, for instance, it is planned to give new connections at the rate of 40,000-50,000 per annum over the 5 years period 1990-1995 - a number greater than the 35,000 households that were connected in the entire Third Five Year Plan (1985-90). Thus even with an added push to gas, its consumption in this sector would probably rise only marginally in 2010 relative to the Base Case. However, beyond 2010 gas supplies

are likely to reach depletion levels and gas imports will probably be required in order to keep the system operating at full capacity.

The situation is different in India. Natural gas plays a very minor role in the domestic sector. The only city whose residences are supplied with natural gas through a distribution network is Baroda in the western state of Gujarat. There are, however, a number of towns and cities located near areas of gas availability where a gas grid could be developed to supply households. In Gujarat, the demand for gas through such a city distribution network is estimated to be in the range of 1.5-2 mmcmd in 2000.[18] Most of these households at present use LPG or kerosene for cooking. Gas can substitute both these fuels.

The demand for LPG in India has been rising rapidly in relation to its availability and a deficit of 1 mt is expected by 1994-95 which is projected to rise to over 2 mt by 1999-2000 in the base case. These estimates of deficit are based on limiting the availability of LPG to specified population centres and are consequently understated. Thus, if this suppressed demand is to be met, LPG imports will be necessary.

Providing reticulated gas distribution systems in metropolitan areas like Bombay and Delhi offers in an option to limit LPG imports. Some estimates regarding its financial and economic viability have been made by the Gas Authority of India Limited (GAIL). The investment required upto the bottling stage for supplying 0.3 mt LPG per annum is Rs.590 crores ($347 million, 1990 prices), while that needed for supplying an equivalent amount of natural gas directly to the burner tip is about Rs.300 crores ($176 million) for a city like Bombay. The gas option would look even more attractive if we add the transportation costs of LPG. It may also be noted that additional energy is required for the extraction of and bottling of LPG.

In the near future, natural gas for this purpose will be available indigenously and the substitution will save on foreign exchange by limiting LPG and kerosene imports. Further into the future gas may need to be imported. It may be noted that these imports do not imply an additional burden since other fuels would have to imported in any case. In fact, at 1990 cif prices LNG after regasification ($3.12/mmbtu) was cheaper than LPG ($4.6/mmbtu).

In order to form an estimate of the amount of LPG and kerosene that might be substituted the following assumptions are made. At present about 50% of the LPG consumed in India is accounted for by the states of Gujarat, Maharashtra, Uttar Pradesh and the city of Delhi. It is estimated that 60% of the energy provided by LPG and kerosene in Gujarat can be substituted by natural gas by 2000.[19] If this share is assumed to prevail in 2010, 786 ktoe of LPG and 749 ktoe of kerosene can be replaced. Studies by GAIL have determined the viability of supplying 0.5 mmcmd and 0.57 mmcmd of city gas to households in Bombay and Delhi respectively. The planned distribution network would supply gas to both industries and households. If these projects are implemented by 2000 then they would substitute approximately one-third of the LPG consumed in these cities in the Base Case. These levels are assumed to hold for all of Maharashtra (the state in which Bombay lies) and Delhi in 2010 also. For Uttar Pradesh, where like Delhi gas will be supplied through the HBJ pipeline, a 10% level of substitution

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[18]Report of the Working Group on Natural Gas Demand and Availability for the Western Region (June 1989). Gujarat Foundation for Development Alternatives.

[19]Ibid.

is assumed. The level of substitution is lower than that of Gujarat because only a few towns in the state of U.P. will be connected with the HBJ pipeline (Table V.4).

| Table V.4: Substitution of LPG by natural gas in households. | | |
|---|---|---|
| State | Level of LPG substitution (%) | Amount substituted in 2010 (mtoe) |
| Gujarat | 60 | 0.786 |
| Maharashtra | 33 | 1.51 |
| Delhi | 33 | 0.375 |
| Uttar Pradesh | 10 | 0.15 |

Based on these assumptions a natural gas demand level of about 4.2 bcm for the household sector in 2010 in India is arrived at.

The Industrial Sector

As in the case of the household sector, the governments of Pakistan and Bangladesh will try to maximise the use of natural gas in the industrial sector subject to the constraint imposed by domestic availability. Despite this the share of gas in the energy consumed by the industrial sector of Bangladesh will decline, from its current level of 78% to 54% in 2010, being replaced by coal. The share of oil will fall from nearly 8% to about 4%. In Pakistan the share of oil will remain roughly constant at 21-22%.

In this alternative scenario, coal in Bangladesh and oil in Pakistan are taken to be the fuels that may be replaced by natural gas. While in Pakistan, this may be viewed as a substitution between two imported fuels in Bangladesh the switch would be between a domestically available fuel and an imported one. Therefore, in Bangladesh the substitution will make sense only if the cost of exploiting domestic coal resources is higher than the price of imported gas. This may well be true given that most of the coal reserves are at great depths and that too under fertile lands or water. Other factors favouring gas would be its greater efficiency, its environmentally benign nature and the fact that Bangladesh would by then have a well developed infrastructure to market gas in almost the entire country.

In India, coal will remain the dominant industrial fuel and gas will mainly be viewed as a replacement for oil. In the Base Case scenario oil (naphtha) is to be substituted by gas as feedstock in the fertilizer and petrochemical industry. For energy purposes, oil and gas together account for about 11.8% of the energy consumed in industry at present. Of this the gas share is 7.5% and the oil share is 92.5% In 2010, oil and gas together continue to provide similar level (11.9%) of total fuel consumed in the industrial sector. However, now the gas share is marginally higher at 9.1% while oil share is 90.9%. This level of substitution can be enhanced.

It is estimated that domestic natural gas can substitute about 50% of the fuel oil used as boiler fuel in industry by the year 2000 in the base case.[20] Thus if gas imports are allowed,the level of substitution might be even higher depending on the relative prices of imported fuel oil and imported gas.

[20] IGIDR, op. cit.

However, it is assumed that a 50% level of substitution continues in 2010. Applying this level to the Base Case demand for fuel oil in 2010, it is seen that 9.6 mtoe is the amount of fuel oil that may be replaced by natural gas (approximately 11 bcm per year).

An interesting development in some countries of South Asia, but particularly in India, is the growing enthusiasm within government circles and the private sector in developing a petrochemical industry. In India per capita consumption of plastics is very low (700 gms) relative to the world average of 15 kg. Given the projections of population growth and growth of GDP, expectations are that demand for plastics will increase sharply. Projections made to the year 2000 for India indicate that consumption will grow at an average growth rate of 8 % p.a. over the 15 year period since 1985. Plastics already play an important role in the various sectors of the economy such as agriculture and water management, teletronics and in building and construction. The Committee on Perspective Planning for the Petrochemical Industry estimated that the level of investment required to meet demand for petrochemical products by the year 2000 is between Rs. 225 - 263 billion (1986 prices) of which 22% is in thermoplastics, 2% is in synthetic rubber, 28% in synthetic fibre, 35% in specialty chemicals and other petrochemicals and 13% is the investment in feedstocks. This level of investment has two implications: (i) that it is beyond the reach of the public sector units in this industry, which has led to a decision to allow private sector involvement in this industry and (ii) that investment will be undertaken provided the investors are assured of regular and adequate supplies of feedstock. If domestic production of C2/C3 is unable to meet ethylene demand, feedstocks will have to be imported into India or more innovative arrangements integrating the producer and the consumer countries in the downstream sector, an aspect that will be taken up for discussion in a later section.

Thus, to summarize the discussion in this section: there is a potential to substitute about 10 - 15% of oil in the transport sector of India, Bangladesh and Pakistan by 2010. (i.e., about 9.4 - 14.2 mtoe) which in gas equivalent terms translates to about 11 - 17 BCM of gas per year. In Bangladesh and Pakistan there is already a considerable shift into gas in the domestic sector, gas share of the sector being 30% in Pakistan and expected to rise further. It is estimated that a gas push will probably increase gas consumption only marginally in 2010 relative to the base case, and a further push would require gas imports. In India, expectations are that gas consumption in the domestic sector could rise to about 4 bcm per year by 2010. In the industrial sector, it is estimated that gas demand could rise to about 11 bcm by 2010; no firm projections were available for 2010 for Bangladesh and Pakistan. Thus, in India, over the base case discussed in the earlier section, increasing gas use would require an additional gas equivalent of about 70 mmcmd. This figure does not take account of new projects in the downstream sector. If this level of gas demand is to be met from indigenous or imported sources, an enormous amount of investment is required for infrastructural supports and for the organization of gas markets. This level of investment raises a number of issues of concern, which will be taken up for discussion in the next section.

## SECTION VI: Bringing Natural Gas to the Market: Issues of Concern

It is clear from the preceding discussion that a number of South Asian countries do have the potential to produce and consume natural gas. Natural gas is seen of relevance to the South Asian economies for two main reasons: one, for its ability to substitute for a large variety of otherwise imported petroleum products and, perhaps for coal on environmental grounds, and two, as an added primary source to meet the needs of these growing populations with their growing aspirations and requirements. The relative economics of coal based power generation as compared to gas based is also not totally unfavourable to gas especially when note is taken of the polluting effects of coal use as will be shown later in this section.

Table VI.1 summarizes the demand for gas in 2010 for the three countries discussed in Sections IV and V in the base case and the gas push scenarios.

**Table VI.1**: Summary of Gas Demand Projections to 2010 (mmcmd)

| | Base Case | Gas Push | Total |
|---|---|---|---|
| India | 110 | 70 | 180 |
| Bangladesh | 58 | 1 | 59 |
| Pakistan | 69 | 10 | 79 |

It is estimated that in India 100-130 mmcmd of gas can be produced by the year 2000 and 165 mmcmd by the year 2010 if necessary capital is available. (Planning Commission) If this indeed be the case there would be no indigenous gas deficit to 2010 for India in the base case but there would be if gas demand is pushed to an additional demand of 70 mmcmd, requiring gas imports. This would not, however, involve any additional foreign exchange as the gas push would be essentially substituting for oil imports. In the case of Pakistan, although reserves may be available to meet base case and gas push scenarios, practices that have resulted in a current stagnation of gas production and possible fall in supplies beyond 2000,[21] create a case for gas imports to supplement indigenous availability. The situation in Bangladesh about gas availability relative to both scenarios is not totally clear although Bangladesh does have gas reserves to support the demand.

In general, a case for gas imports can be made (1) to ensure investor confidence and to allow the development of gas markets (2) for diversity of supply considerations and (3) if the gas push has to be accelerated for environmental reasons. It is thus important to start putting the necessary infrastructure in place for such imports given the large gestational lags involved in such projects. This is essential to avoid bottlenecks that may emerge for two reasons: (1) because as seen in section I competition for gas supplies in the Asia- Pacific region is expected to rise sharply in the next decade, (2) to ensure that gas utilization systems already in place or are likely to be in place by 2010 are operating at capacity. In this section, we raise a number of concerns that emerge in bringing both indigenous and imported gas to the market.

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[21] Imran and Barnes, op cit, p 35

Current thinking in India, and that which governed gas development policy in Pakistan and Bangladesh for the last two decades does in fact favour the development of the respective country's indigenous reserves of natural gas to meet not only requirements where an energy deficit already exists but also to use it as a base for the development of new industries. In line with this thinking, for example in India, in the last few years a number of power, fertilizer and LPG plants and petrochemical units are at various stages of planning and implementation. In 1990, it was estimated by the Gas Authority of India Limited (GAIL) that Rs.29,000 crores in 1990 prices would be required to be invested in the downstream industries, namely, power, fertilizers, sponge iron and the petrochemical industry during the period 1990 - 2000 to utilize natural gas effectively.

Bringing natural gas to the market because of the scale and the nature of investment required for its development and marketing in these countries raises some important issues of concern especially for new entrants into the industry:

(i) **the level of the indigenous natural gas resources** could prove a deterrent to investment, if domestic investments are being planned based on projections of domestic availability. The uncertainty about continued and regular supplies of natural gas may hamper the development of gas infrastructure and a market to absorb this gas. However, as long as infrastructure and the market are not in place, indigenous reserves will not be developed, given the rigid link that exists between gas reserves and gas markets. To break into this circle, it becomes necessary to assure potential investors, both in infrastructural and gas based industrial projects that supplies will be available on a long term, that is over 20-25 years. It is in this context that importing natural gas from neighbouring countries to supplement indigenous availability becomes of crucial relevance.

(ii) In order to allow commitments and investment to take place there is **need for a transparent pricing policy** based on the following main principles: (a) producer prices that encourage efficient production and transportation of natural gas and (b) consumer prices that will not affect demand schedules but allow for interfuel substitution into gas. The price fixed for the producer can employ a modified form of marginal cost pricing to which are added values that take account of the scarcity value or user cost. The price to the consumer can be either cost-based or linked to the price of the fuel replaced. The latter option is especially attractive when gas markets are being created.[22] However, once the market is well established, the principle underlying pricing should be cost-based to reflect resource scarcity. Linking gas prices to the alternative fuel replaced does however imply differentiated pricing. It was pointed out recently, that for countries such as India, adopting this approach may be difficult for a number of reasons:[23]

(a) that for long term development of the gas sector a pricing formula that is transparent and easy would enable downstream industry to make the necessary investments

(b) that differentiated prices would be very difficult to implement because of the need to monitor every end-use of gas.

[22] For example, in France, Gaz de France prices natural gas lower than gas oil, the main fuel displaced there. In the US, the price of gas tends to track the price of residual fuel oil at the burner tip, because the major competitor to natural gas is fuel oil in industrial and utility uses.

[23] GOI, 'Report of the Committee on Pricing of Natural Gas', New Delhi, May 1990, pp 53-54.

(c) the determination of the opportunity cost is complex in cases where the monopoly supplier is also an user in the downstream industry as is the case of Gas Authority of India.

(iii) That **gas developments require dedicated assets** and so it becomes necessary to enter into long term contracts that are binding. It is important to realize that although gas and oil are joint operations at the exploration phase and where gas is in an associated form at the production phase, downstream gas development is very different from downstream oil development. Oil is easily divisible, storable and tradeable. Not so natural gas, as it requires long term commitments in production, transportation and marketing chains, because the form of investment is often of a dedicated nature. Assets that are put in place in a gas chain, whether it be LNG or pipeline gas are those that are put in place contingent on particular supply arrangements. This is necessary not only for securing the necessary front-end financing but also to ensure long term financial viability. Should such contracts be prematurely terminated, the investing firm is faced with significant excess capacity.[24]

(iv) the **level of gas input value** is a major factor in determining the viability of a gas transmission and distribution project. This is especially so in the case of imported pipeline or LNG, as is shown later in this section, where the project is constrained by the volume and the price terms of the contracts between the producer and the consumer over a long term.

Importing LNG or Pipeline Gas

There has been very little international movement in gas relative to oil essentially because gas is so much more difficult to transport and store. Pipeline trade accounts for 76.6% of gas movements in international trade and LNG for 23.4%, although in terms of natural gas that is produced the former comprises only 10% while the latter comprises about 3%. The main gas movements are to West Europe for pipeline (60%) and to the Asia Pacific region for LNG (72% of all LNG trade) Pipeline trade involves 25 importing countries and 12 exporting while LNG concerns eight exporting and 9 importing countries. Germany is the largest importer of pipeline gas (25%) while the erstwhile USSR is the largest exporter (47%). Indonesia is the largest LNG exporter (38%) and Japan the largest importer (66%) The tables below summarize the present status of natural gas trade movements by pipeline and LNG (Tables VI.2, VI.3).

**Table VI.2** Natural Gas Movements by pipeline in 1990 (BCM)

| | Total Imports | Total exports |
|---|---|---|
| North America | 42.82 | 42.8 |
| W.Europe | 139 2 | 63.5 |
| Ussr and E.Europe | 48.2 | 110.4 |
| West Asia | 2.0 | 4.3 |
| Africa | 1.3 | 12.4 |
| Total | 233.5 | 233.5 |

Source: See table below.

[24]. For a discussion of dedicated investments and means by which to support and promote exchanges in such assets see, O.E.Williamson, 'Credible Commitments: Using Hostages to Support Exchange' in The American Economic Review, September 1983, vol.73, no. 4, pp 519 - 540.

| Table VI.3: Liquified Natural Gas Trade Movements 1990, (BCM) | | |
|---|---|---|
| | Total Imports | Total Exports |
| North America | 2.5 | 1.4 |
| W. Europe | 17.7 | - |
| N. Africa | - | 20.3 |
| Asia _ Pacific | 52.0 | 47.3 |
| West Asia | - | 3.2 |
| Total | 72.2 | 72.2 |
| Source: **BP Statistical Review Of World Energy 1991 and** CEDIGAZ, **World LNG Trade**, November 1991. | | |

LNG trade is expected to grow very sharply in the next 20 years rising to 179 - 216 BCM by 2010 (CEDIGAZ) with power generation being the driving force behind this growth. Limits to the future growth of pipeline trade are seen to be physical distances of the consuming from the producing centres, topography and national security considerations.

LNG import projects involve heavy investment in gas gathering, liquefaction at the producer end, heavy investment in the mode of LNG transport and regasification at the consumer end. CEDIGAZ estimates that a new LNG project with a capacity of 6-8 BCM/year would require a financial commitment of $5 billion in 1991. A major factor in determining the viability of the project is the wellhead price of natural gas that is fed into the project. Project promoters tend to demand guarantees to ensure financial profitability. The main means to ensure this profitability is to have long term contracts, take or pay clauses and the determination of a base prices that will hold (with some adjustment) throughout the duration of the project.

The base price is a must in such contracts whether determined FOB, CIF or ex-ship (delivered before regasification) In general the trend in international LNG trade is to index the base price to representative prices of the energy market, where the indexing is subject to periodic renegotiations.

In the 1970s, the base price in the European market was indexed to prices of petroleum products, and posted prices of crude oils on the Japanese market. Since the 1980s, the base price has been indexed to the price of crude. The three main regional markets for LNG trade are Japan, Europe and the USA. The tables below provide an indication of LNG prices in the main markets and a comparison of competing gases or other fuels and gases in each regional market (Tables VI.4, VI.5, VI.6, VI.7). Thus, in Japan, LNG competes with other petroleum products and crude oil, in the US it competes with Canadian and American gas and in Western Europe with pipeline gas from Norway and the Netherlands.

| **Table VI.4: July 1991 trend in LNG prices CIF before regasification ($/mmbtu)** | |
|---|---|
| USA (Algeria) | 1.60 - 1.85 |
| EUROPE (Algeria - France) | 3.13 |
| JAPAN (Indonesia) | 3.56 |
| JAPAN (USA) | 3.61 |
| SOUTH KOREA | 3.57 |
| Source: CEDIGAZ, **World LNG Trade**, November 1991. | |

**Table VI.5**. Comparison of CIF prices of Fuels in Japan ($/mmbtu)

| Year | Crude | LNG | [illegible] | Coal | Fuel Oil |
|---|---|---|---|---|---|
| 1990 | 3.82 | 3.61 | 3.67 | 1.99 | 3.64 |

Source: Same as the table above

**Table VI.6**: Comparison of average gas costs on the US market ($/mmbtu)

| Year | American gas (wellhead price) | Canadian gas (FOB) | LNG (CIF) |
|---|---|---|---|
| 1990 | 1.72 | 2.03 | 1.55 - 2.65 |

Source: same as the table above

**Table VI.7**: Comparison of gas import prices in western europe ($/mmbtu)

| Year | Netherlands (FOB) | Norway (FOB) | Algerian (CIF,France) |
|---|---|---|---|
| 1990 | 2.73 | 2.01 | 3.23 |

Source: same as the table above.

This study attempted to estimate the costs of imported LNG into the South Asian region from new LNG chains. Capital investment data is taken from the 1991 CEDIGAZ report on **World LNG Trade.** O& M costs are assumed at 5% of capital costs; economic lifetime is taken to be 30 years and a discount rate of 10% is used to calculate the cost recovery factor.

**Table VI.8: Costs of Establishing an LNG Liquefaction plant**

| | |
|---|---|
| **a. Data for Capital costs** | |
| - Capital costs (US $ Million) | 2500 |
| - Annual gas handling capacity (BCM) | 10 |
| - Unit capital costs ($/Cu.m) | 0.25 |
| - Annualized capital costs ($/Cu.m) | 0.027 |
| b. Data for O & M Costs (@ 5% of a) | |
| -Annual O & M costs (US$ million) | 125 |
| - Annual gas handling capacity (BCM) | 10 |
| - Unit O & M costs ($/Cu.M) | 0.013 |
| c. Annualized capital costs plus annual O & M costs | |
| ($/Cu.M) | 0.04 |
| ($/t LNG) | 54.0 |
| ($/mmbtu) | 1.1 |

**Table VI.9**: Costs of Regasification

| | |
|---|---|
| a. Data for Regasification costs | |
| - Capital costs incl. port facilities (US$ Million) | |
| - Gas handling capacity (BCM) | 400 |
| - Unit capital costs (US $) | 4 |
| - Annualized capital costs | 0.1 |
| ($/Cu.m) | |
| | 0.0106 |
| b. Data for O & M costs | |
| - Annual O & M costs ($ million) | 20 |
| - Handling capacity (BCM) | 4 |
| - Unit O & M costs ($ cu.M) | 0.005 |
| c. Annualized capital costs plus O & M costs | |
| ($/Cu.m) | 0.015 |
| ($/mmbtu) | 0.42 |

| Table VI.10: Costs of LNG transportation | |
|---|---|
| **a. Data for capital costs** | |
| - Capital cost of an LNG carrier of 125,000 Cu.m (US$ million) | 150 |
| - annual transportation capacity (20 voyages) (BCM) | 1.4 |
| - Annualized capital costs (at 10%, 20 years) ($/Cu.m) | 0.013 |
| b: Annual O & M costs | |
| - Annual O & M costs (3.75%) ($ mn) | 5.6 |
| - annual transportation capacity (BCM) | 1.4 |
| - Annual O & M costs ($/Cu.m) | 0.004 |
| c. Annualized capital plus O & M costs | |
| ($/Cu.m) | 0.17 |
| ($/mmbtu) | 0.48 |

It is estimated that annual fuel costs for a distance of 3500 miles are around $0.4/mmbtu making total transportation costs average $0.8/mmbtu.

| Breakdown of costs along an LNG chain (US$/mmbtu) | |
|---|---|
| Liquefaction | 1.1 |
| Transportation | 0.8 |
| Regasification | 0.45 |
| Total: | 2.35 |

Using the above estimates, an attempt was made to compare the costs of using coal and imported Qatar LNG at a power plant on the west coast of India, say Mangalore, assumed to be at a distance of 1000 kms from the coal mines. The cost comparisons are given in the table below.

| Table VI.11: Comparative cost of a coal based TPS and an LNG based CCP | | |
|---|---|---|
| | Coal-based TPS | LNG based CCP |
| Installed capacity (MW) | 420 | 352 |
| Unit capital costs ($/kW) | 1000 | 769 |
| Lifetime (years) | 25 | 15 |
| Hours of generation per year | 5500 | 5500-5700 |
| CRF at 12% | 0.1275 | 0.1468 |
| Annualized capital costs$/kW) | 127.5 | 112.9 |
| Unit O & M costs ($/kW)(2.5% of capital costs) | 25 | 19.2 |
| Annualized capital costs plus O & M costs ($/kW) | 152.5 | 132.1 |
| **1.Per unit costs of generation (cents/kWh)** | **2.77** | **2.32-2.4** |
| Fuel costs<br>(cent/kg) - coal<br>(cent/scm)- gas | 3.1-3.85 | 10.19 - 10.69 |
| Fuel requirement/kWh<br>Coal/gas<br>Fuel oil | 0.65 kg<br>7 ml | 0.2815 cu.m |
| **2. Fuel cost/kWh (cents/ kWh)** | **2.1-2.6** | **2.87 - 3.01** |
| **Total cost (1 + 2) (cents/kWh)** | **4.87-5.37** | **5.19-5.41** |

Assumptions used:

(1) Current costs of delivered coal to Mangalore is taken to be $30.8 - $38.5/tonne.

(2) c.i.f. regasified gas costs assumed to be in the range of $2.85 - $3.00/mmbtu

(3) A discount rate of 12 percent is used in accordance with the normal approach followed for economic evaluation of public investment projects in India.

The above analysis yields per unit costs of generation for the two systems. It is evident that the price of the feed gas is crucial to the choice. Thus, the case for gas based power generation at Mangalore, based on the above cost estimates is not totally clear. However, the situation may change if environmental and other considerations are taken into account. It has to be noted that if pollution control costs are to be added, costs of coal based generation would rise, since costs of particulate removal and ash disposal would have to be added to these generation costs.[25] However, both the

[25]. For example, in TERI, 1991 (b) pollution costs of particulate emissions were estimated per unit of electricity generated. If this is added to the total economic costs of generating electricity, this would have to be increased by 0.1 cent/kWh. Moreover if a higher figure is assumed for annual hours of generation for a CCP, the costs for LNG based CCP will fall to $4.93/mbtu.

systems would require controls of sulphur, if the gas has not been sweetened and nitrogen control costs.

**Assessing the costs of gas imported by Pipeline**

To assess the costs of pipeline gas into countries of the South Asian region a preliminary exercise was carried out using the data for **Asian Pipeline Project: A Preliminary Evaluation.** The data is for a pipeline running from Iran through Pakistan into India, over a distance of 3300 km, designed to carry 100 mmcmd of natural gas. The whole system consists of a gas gathering system, a gas processing plant and compressor stations and the pipeline itself. Since no costs of feed gas were available, the cost of feed gas to be used in the Qatar project were assumed for comparative purposes, that is, \$0.5 - \$1.0 mmbtu. This could well turn out the range of the cost of feedstock gas, as one of the options for the gas for the project is to tap the joint Qatar/Iran north field. The gas processing plant capital costs were assumed at \$500 million designed to handle a capacity of 100 mmcmd. Pipeline costs for the segment from Iran through Pakistan to the shores of India were taken involving an investment of \$7350 million for a pipeline length of 1700 km and a throughput capacity of 80 mmcmd. O & M costs were assumed to be 3% of capital costs.

Total costs of gas imported by pipeline at the port of import using a feedgas cost of \$0.5/mmbtu is estimated to be \$1.54/mmbtu. If a higher cost of feed gas is assumed the costs rises to \$2.04/mmbtu. It is clear that if security implications and political considerations are not taken into account, pipeline gas is cheaper than LNG.

Financing LNG/Pipeline Projects

LNG/pipeline projects are complex, very capital intensive, involving high front end capital costs which could account for about 60-80%of the entire project costs. Financing of these projects are, therefore, one of the most difficult aspects of the whole enterprise. In general, the trend has been to have a group of sponsors raising the required finances. In such arrangements, one observes a large contribution coming from the financial institutions of the countries of the project sponsors. For example, it is evident that one of the main factors for the development of Indonesian LNG export projects to Japan was the availability of Japanese finance for the projects, supported by assistance from Indonesian financial institutions. Such financing can be a combination of debt financing and export credits, since a large portion of the project involves capital goods.

The table below provides information of the sources of financing in phase I of Arun and Badak LNG projects in Indonesia by way of illustration (Table VI.12).[26] It is evident from the table that over 86% of the total project costs was provided by the Japanese. A key component of the success of Japan's LNG imports has been the involvement of Japanese trading houses, for example, Mitsui, Nissho Iwar and Mitsubishi. While the involvement of these houses was due to a lack of experience in

26. Arun and Badak are owned by the original participants to the gas contracts, i.e., Pertamina who is both a partner with the production sharing contractors and owns the rights to the gas on behalf of the government, the Japanese customers, and the production sharing contractor who supply the gas.

international negotiations on the part of the Japanese utilities, their involvement also facilitated the arrangement of necessary financing.[27]

| Table VI.12: Sources of Financing of Arun and Badak Projects (Phase I) | | | |
|---|---|---|---|
| **Sources of Funds** | **Currenty given** | **Intermediary institutes** | **Amount (US$ mn)** |
| EXIM Banks and Japanese private banks | US dollars | JILCO | 1129 |
| Japanese LNG buyers | Yen | JILCO | 91 |
| Japanese govt./OECF | Yen | Bank Indonesia | 187 |
| Indonesian govt. | US dollars | Bank Indonesia | 90 |
| Indonesian govt. | Rupiah | Bank Indonesia | 91 |
| International commercial banks | US dollars | Bank Indonesia | 50 |
| Total funds (incl. construction period) | | | 1638 |

Source: R.O. Hutpea, 'Financing of Natural Gas Export Projects in Developing Countries: The Indonesian Experience' paper presented at the 8th International Conference on LNG, Los Angeles, CA, USA, 15-19 June 1986.

The financing options for such projects are mainly aid, export credits, debt and equity financing, with aid being the least costly source of finance but also the least flexible and equity being the most flexible and expensive. All of these options may not, however, be equally available to developing countries. For example, while export credits are relatively easy to obtain, aid and debt financing are not so. Borrowing from commercial banks will depend on whether the country fulfils the criteria which the bank applies. These include the level of its existing exposure to the country, including any earlier difficulties with repayment, the degree of political risk perceived for the country and the bank's view about prospects for the local economy including any balance of payments problems.[28] Banks generally prefer the finance to be directed to a specific project which will generate export earnings or substitute imports rather than to give a loan for general development purposes. In general, a project's financial structure will comprise some, if not all, of these options.

The general approach to gas pipeline/LNG project financing especially where the pipeline is to be owned by a group other than the gasfield operator is to include throughput guarantees in the financing conditions. Since very often gas contract payments are made in a currency other than that in which the loan and/or expenditure is made, there is generally a clause put in to cover exchange risks. This can be in the form of a higher cover ratio, by payment at an exchange rate fixed to the drawdown

[27]. B. Kiani, 'LNG trade in the Asia-Pacific Region: Current Status and Future Prospects', Energy Policy, Jan - Feb 1991, pp 63-75.

[28] Source; Barclays Bank PLC, London

rate or even a series of long term forward currency swaps. Throughput guarantees for pipelines and long term sales contracts for LNG projects with acceptable exchange risks tend to be the norm in such projects. 'Take or pay' clauses are also often found in such financing. In its simplest form, such a clause would require the buyer to take and pay for a specified quantity or to pay for that quantity whether taken or not. With this assurance of a minimum cash flow, the producer can expect not only a certain return on his original investment, but also the financial capability to borrow and repay loan amounts.

In general, foreign banks tend to be very cautious about providing finance where the local risks are considered to be relatively high and the release of foreign exchange for loan repayment may be difficult. It is in this area of financing that the multilateral institutions such as the Asian Development Bank, the World Bank, etc. have a role to pay. So far the World Bank or the International Fiance Corporation have not been involved in the financing of a pipeline or an LNG project, but there is no real reason for them not to be involved.[29] As in the case of the development of oilfields, the presence of the World Bank in a project may well reassure the more hesitant of the commercial banks for, one, they may see the country as a credit-worthy country and, two, the presence of the Bank may be seen as a means to ensure that governments would not renege on their promises, since it would not like to offend the Bank. The presence of the Bank tends thus to reduce the risk premium for investment. Therefore, projects for which commercial banks would not previously lend money, become more attractive because of the Bank's presence

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29. K. McKeough, **The Status of Liquefied Natural Gas Worldwide**, [Energy Development Division, Industry and Energy Department], The Word Bank, March 1990, p 9.

## SECTION VII: Trade in Energy Related Industry

The Downstream Industry

In section V, reference was made to the need of innovative arrangements that have to be given some consideration in countries of South Asia in the downstream sector to enable these countries to overcome their lack of investment funds and to assure the investors of regular supplies of feedstock. On the other hand, in section I it was seen that OPEC countries needed to have some assured market for their oil and gas as also opportunities for diversification of their economies.

One such possible arrangement is the integration of producer - consumer countries in the downstream sector.. There are two possible options in this area:

(i) the integration of OPEC members (in particular those of West and South East Asia) in the downstream sector of the South Asian countries and

(ii) the integration of the South asian countries (as consumers) into the downstream sector of some OPEC members.

(i) This investment possibility is analogous to OPEC's involvement in the refining sector of the industrialized countries in the 1980s. OPEC had a 15.6% level of oil integration in 1980, i.e., the share of crude supplied to local and foreign refineries relative to its crude oil production. Over 10 years this figure more than doubled with the share rising to 36% in 1991 and expected to rise to 40% with the resumption of refining operations in Kuwait and Iraq.[30]. Of the member countries, Venezuela has the largest foreign refinery holdings within OPEC, comprising 58% of the OPEC interest in foreign refinery capacity. Saudi Arabia follows with 17.2%, Abu Dhabi, Libya and Kuwait with 6-8% each.

It is argued that the penetration by OPEC of the down stream sector of the industrial countries was possible because of a peculiar configuration of factors:

(1) the withdrawal of some of the majors from the European downstream sector in the early 1980s as part of the restructuring process

(2) the sharp rise in oil prices in 1978/79 and then a decline between 1980 - 85 which occurred too slowly to permit refiners to return to their earlier profitability

(3) the surplus refining capacity and the fall in demand for petroleum products during that period

(4) the search by producers for guaranteed export markets

(5) the liquidity of the producer countries arising from the high oil prices.[31]

It is argued that these factors no longer hold in the international markets as refining margins have remained positive since the end of 1985, demand for refined products has been rising, albeit slowly, and expected to rise further, the more difficult phase of the restructuring process in the industrialized countries is over and producer countries are no longer as flush with funds as they were in the era of high oil prices.

Notwithstanding all these arguments, it can be said that while opportunities in the industrialized world might have narrowed down, there is still opportunity for such investments in the countries of the developing world, especially those of the South Asian region and the former CPEs, whose requirements

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30. OPEC Bulletin, September 1991

31. P. Terezian, 'Integration of the Producer Countries in the Foreign Downstream Sector of the Consumer Countries, OPEC Bulletin, September 1991, p 10.

of petroleum products are rising and refining capacity is unable to keep pace with this demand. For example, in Pakistan, three domestic refineries meet only 50% of local requirements of petroleum products. This has led Pakistan to enter into a joint venture arrangement with Iran for a 120,000 bbl/d refinery at Karachi. In India, refining capacity meets 88% of product consumption but expectations are that this share will fall in the future. There is also a large potential for investment in the fertilizer and petrochemical industry, which as was seen earlier in the study are the sunrise industries in the region and requiring massive investments. Such investments will also enable the producer countries to have some certainty of secure markets for the feedstock and the finished product.

(2) An alternative arrangement that is, for example, being mooted in India, is for those developing countries that have the technological capability to establish gas based downstream plants in the fertilizer and the petrochemical industry in West Asia. The argument for this kind of arrangement is that since the costs of feedstock for these industries are about 8-10 times higher in countries such as India than in the countries of West Asia, the cost per tonne of urea produced is about three times higher than in the international market. The case for setting up such offshore gas based plants thus lies in (i) the lower costs of the feedstock, (ii) the existence of dedicated markets for the finished product in India, (iii) lower per unit production costs, (iv) the existing technological capability in the consumer country and (v) the provision of an assured market for the host country's gas.

A careful analysis has to be made of the comparative economics of these options so that arrangements entered into between the producer and the consumer country reflect the relative concerns with regard to security of supply, security of demand, risk-sharing, diversification into a more broad-based economy and the cost effectiveness of the locational choice.

## Trade in Energy Equipment and Services

The OPEC countries of West Asia and those of North Africa have accounted for over 40% of total industrial project exports from South Asian countries, in particular from India. Investments have tended to be concentrated in infrastructure related power projects, i.e., power generation, transmission and distribution projects. Libya has been the largest destination followed by Iran, Iraq and Saudi Arabia. The Indian firms that have been active are the two public sector firms, Bharat Heavy Electricals Ltd (BHEL) and Engineering Products India Ltd (EPIL) and Tata Exports in the private sector.[32]

While the focus has hitherto been on the power equipment and services sector, another potential avenue for trade is in oilfield equipment and services. If there is to be a large increase in productive capacity in OPEC over the next 10 years and beyond, there is enormous potential for this industry. In recent times, there has been considerable growth in the oilfield equipment and services industry, especially in India and Pakistan. The industry broadly includes consultancy, exploration services, drilling, fabrication, installation, pipe laying, underwater engineering, electrical logging, wire line and well testing services, cementing and stimulation services, mud supplies and mud services, oilfield chemicals, and directional drilling.

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[32]. The term 'project export' is used here in the sense used by S.Lall to denote the setting up of industrial plants where the sellers provides both the equipment and part or all of the services involved in design, detailed engineering, procurement, civil construction equipment, installation, commissioning and training of the local labour force. S.Lall, World Development Report, May/June 1984, p 536.

The Indian oilfield equipment and supply has become quite well developed with local participation in a number of sectors as is observed in Appendix I. However, as was noted in a detailed study on the industry, one of the main factors limiting the growth of the industry in the late eighties was its dependence on a single purchaser, the Oil and Natural Gas Commission.[33] There were no commitments or assurances of demand given to indigenous industry, the general approach that was favoured being its development in competition with international industry.

In general, oil companies have either favoured turnkey contracts or chain arrangements when contracting for exports of this industry. A turnkey project may vary according to the project, but would, in general, place on one party 'the responsibility for supply and establishment of the works, plants and facilities on a turnkey basis, including supply of technology and know-how, basic design and engineering, supply of complete plant and equipment, design and construction of civil works, complete erection of plant and equipment and commissioning of the total plant facilities up to the stage of start-up'.[34] Chain arrangements, on the other hand involve several companies. The choice between the two depends very much on the managerial time and capability available to the contracting oil company.

To be able to compete with international industry, however, the main pre-requisite is investment in plant capacity and technology. To invest in efficient plant and avail of economies of scale, the equipment firms require sizeable outlays. For the required capital, they have to tap the banks and the financial institutions for funds. These lending institutions in turn require that the borrower have some assurances regarding future orders which national oil companies find difficult to give local industry until they are assured of the quality and the delivery schedules of local firms, which is again linked to their investment in plant and technology. In the development of the Indian industry thus, it was observed that the lock-in effect into the national oil company and the consequent inability to avail of scale economies was one of the main reasons limiting its growth. This also reduced their ability to attenuate fluctuations over time of demand. It was evident that an export orientation was essential to serve as an additional source of demand for local producers, and that policies to support this were as important as those to substitute imports.

Given the enormous potential demand that exists in OPEC for these oilfield equipment and services and given that the local industry in most of these countries is either undeveloped or underdeveloped, there is considerable scope for trade in such equipment and services between countries of South Asia and OPEC.

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[33] L. Noronha, 'Policy-Making in the Indian Offshore Oil Industry with Reference to the Period 1974 - 86', unpublished PhD thesis, LSE, University of London, 1988, chapters 5 and 6.

[34] UNCTC **Features and Issues in Turnkey Contracts in Developing Countries: A Technical Paper**, 1983, p 6.

## Conclusions

This study was an exploration into energy trade possibilities between countries of the South Asian Region and OPEC with a special focus on natural gas. The main tenet of the study was that trade between these two groups of countries would be of mutual benefit to both because it would address a common concern that has tended to impede gas development. In OPEC, uncertainty about demand for not just its gas, but more so for its oil has led to its reluctance to invest in new productive capacity. In SAC, especially in India, lack of gas markets has tended to impede production of indigenous gas. Uncertainty about gas supplies to sustain the markets that are developed beyond a couple of decades has hindered investments in gas based industry. Planning for a gas market in India and other South Asian countries with the gas import option as a definite supply support would go a long way to increase investor confidence in gas based industry and allow for necessary infrastructure and assets to be put in place contingent on this supply.

The study has thrown up a number of issues that need to be addressed more closely:

(1) The relative advantages of locating gas based industry in SAC or OPEC, or an optimum mix for both options;

(2) The combination of financing options for LNG/pipeline gas trade that are most beneficial from the point of view of these two groups of countries;

(3) Fiscal and other incentives necessary to promote gas developments at the investor end;

(4) Fiscal and other incentives necessary to encourage behavioral changes necessary for a shift to gas at the consumer end.

The next phase of this study could take up these issues.

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**APPENDIX I**

**Indian Company Involvement by Selected Sectors**

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|---|---|
| **Rig Construction** | **Bharat Heavy Electricals Ltd. Mazgaon Docks Ltd., Hindustan Shipyard Ltd.** |
| **Platform Fabrication** | **MDL, Burn standard Co. Ltd, HSL.** |
| **Construction of Supply** | **Goa Shipyard Ltd, HSL, Hooghly Docks & Port & Service Vessels Engineers Ltd.** |
| **Process Control Equipment** | **Fouress Engineering (I) Pvt. Ltd, Ingersoll - Rand., K.G.Khosla Compressors Ltd.,Thermax Pvt. Ltd., Chemtrol Engineering, Bharat Pumps & Compressors Limited.** |
| Drilling Bits & Equipment | Greaves Cotton & Co., BHEL, Triveni Plenty Engineering Ltd., Precision Drilling Equipment Ltd. |
| X'mas trees and wellhead Assemblies | Audco India Ltd., BHEL. |
| Mud and salt Water Pumps | BPCL |
| Fire Fighting Equipment | Mather & Platt (I) Ltd |
| Casing Tube Co., | Indian Tube Co. Ltd, Tata Steel, BHEL, Indian Seamless Metal Nuclear Fuel Complex |
| Test Separators | Triveni Engineering, Thermax Pvt.Ltd |
| Geophysics | Oil and Natural Gas Corporation |
| Oceanographic | National Institute of Oceanography |
| Navigation & Positioning | Elcome Marine |
| Diving Companies/Maintenance Repairs & Underwater Services | Dolphin Offshore, Essar, Duke Offshore, MDL, |
| Logistic Support | Essar, Shipping Corporation of India, Garware shipping, Great Eastern Shipping, Indian Steamships, Shaw |
| Wallace & Co. Ltd. Civil Construction Works | Essar Constructions Ltd. |
| Engineering Consultancy | Engineers India Ltd. |
| Installation | Essar |
| Pipe laying | Essar, Dodsal Private Ltd. |